
MNT REFORM
OPERATOR HANDBOOK
MNT REFORM

Contents

Chapter 1

Preface

Early in the MNT Reform project, we made—working in the kitchen—13 prototypes for us and a handful of adventurous people. These were much more primitive predecessors of the laptop that you received today, based on an older processor and an eclectic mix of materials. Each already came with an *Operator Handbook:* 30 manually bound pages of schematics and instructions for handling the prototype. It was but a rough sketch of the book that you are reading now.

The original handbook turned out to be an icebreaker and conversation aid when talking about MNT Reform with other people. We wrote this new handbook in the same spirit: to make your MNT Reform more approachable, understandable, but also more discussible. The book will be your companion when taking MNT Reform apart and learning the basics of using the machine.

At a time when electronics are becoming ever more secretive, MNT Reform and this book buck the trends—but they are not sacred artifacts. They are meant to be taken apart, discussed, hacked, built upon. Scribble in the margins. Make it your own.

Chapter 2

Safety & Environment

2.1 Hazards

Before you get started with your MNT Reform, please read these safety instructions carefully to prevent harm to yourself and your environment.

Electrical Shock and Fire Hazard: Please be extra careful while and after opening the case of the device. MNT Reform uses 8 batteries in series. When fully charged, these combine to a voltage of almost 29 volts, and the battery cells can easily deliver multiple amperes of current. Do not touch the metal pins of the battery holders with metal tools.

Before servicing anything on the inside, make sure that the wall power is unplugged and remove all battery cells.

Damage to Hearing: The headphone output of MNT Reform can be forced to extreme volume which may damage your hearing if you are not careful. Please make sure to set the volume to 30% or less before connecting headphones to MNT Reform, and then adjust the volume to a comfortable level.

2.2 Recycling

Don’t throw any MNT Reform parts in the trash! Batteries and electronics contain materials that are harmful to the environment if not properly disposed of.

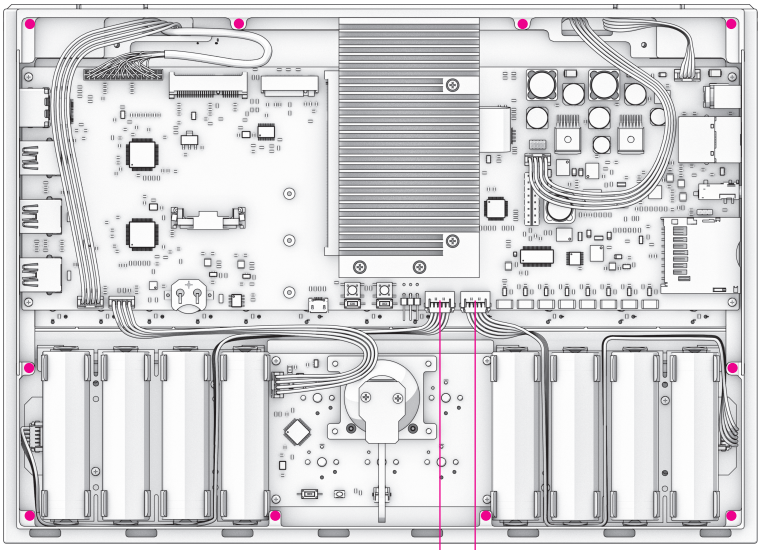
You can mail any of the parts back to MNT Research, and we will recycle them for you. Alternatively, you can recycle batteries at a local battery collection facility and dispose of electronics and cables at a local e-waste facility.

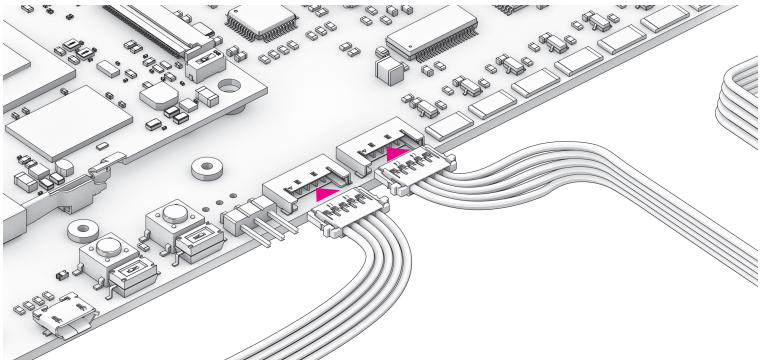
Chapter 3

Quick Start

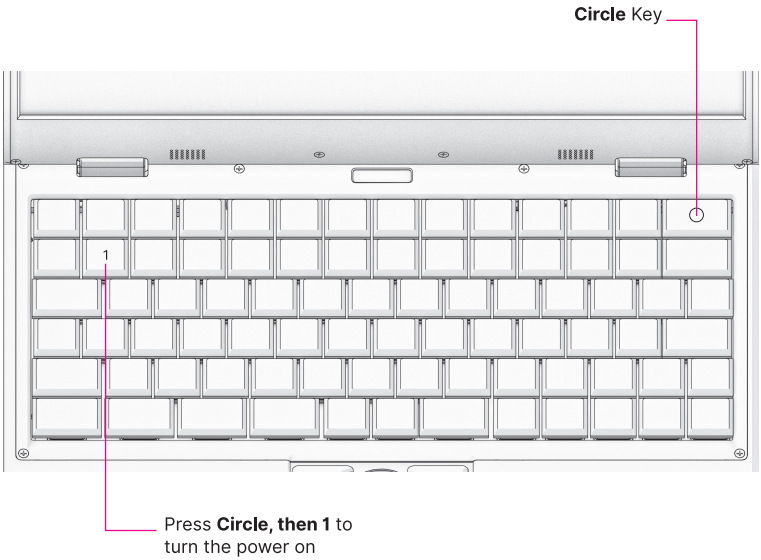
3.1 Step 1: Connect Batteries

To prevent discharge during shipment, the battery cables are not connected by default. After reading about **Safety** in chapter 2, unscrew the 10 bottom screws and remove the bottom plate. Attach the two battery cable plugs to the battery connectors on the motherboard, then reinstall the bottom lid.


Bottom Case Screw ×10
Battery Connector 2
Battery Connector 1



3.2 Step 2: Turn On



First, insert the included SD card into the slot on the left hand side of the device.

Then, to turn Reform on, press **Circle** and then **1**. The **Circle** key is used for system control commands. When you press **Circle**, a menu of system control functions and their shortcuts will be displayed on the OLED screen embedded in the keyboard.

3.3 Step 3: Log In

After being powered on, the main processor will boot the operating system installed on the inserted SD card. The operating system's kernel will show diagnostic information as it

activates all the devices in the system until finally arriving at the login prompt. Enter `root` as the username at the prompt. There is no default password, so you will be logged in immediately.

From here, you can begin installing software and using MNT Reform. If you are new to the Debian GNU/Linux operating system or want to learn about specifics of the system software shipped with MNT Reform, please refer to chapter 5, “Linux Basics”.

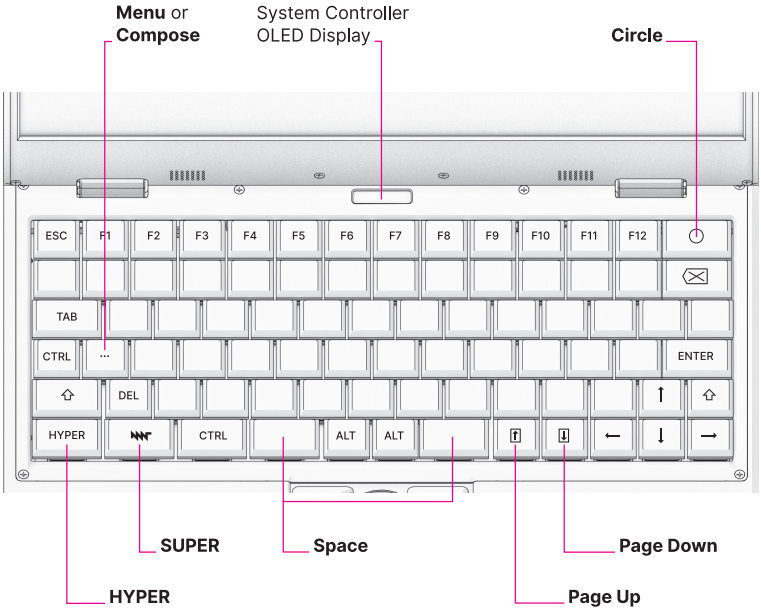
The following chapter will introduce you to the input devices of MNT Reform.

Chapter 4

Input Devices

MNT Reform comes with a keyboard and either a trackball or a trackpad preinstalled. All of the input devices are modular and can be easily swapped in and out. They all connect via internal USB 2.0 cables.

4.1 Keyboard



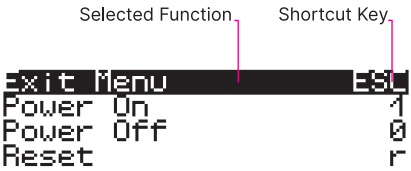
The layout of the MNT Reform keyboard is slightly unusual. We simplified the traditional typewriter-based layout so that the keyboard can be constructed using only two distinct key shapes (square and 1.5x). This removes the need for mechanical stabilizers for long keys and makes it easier to customize and swap keycaps to your liking.

The biggest difference is the split spacebar: instead of one long key, there are two 1.5x wide space keys, with left and right Alt keys sandwiched between them. Because many advanced users remap the traditional Caps Lock key to a different function, we swapped Caps Lock for a *CTRL* key.

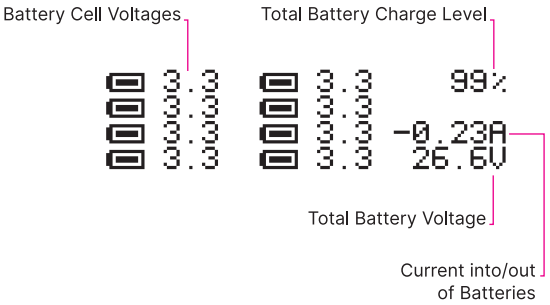
This makes the use of *CTRL* key combinations more ergonomic.

Next to the *CTRL* key is a key with 3 dots (an ellipsis). This is normally the Menu key, but on the default MNT Reform system software, it is mapped to *Compose* (a key that allows you to generate Unicode symbols from Compose sequences). Lastly, MNT Reform features an additional modifier key, the *HYPER* key, in the lower left. The idea is to let you assign this key to whatever function you require.

4.2 OLED Menu

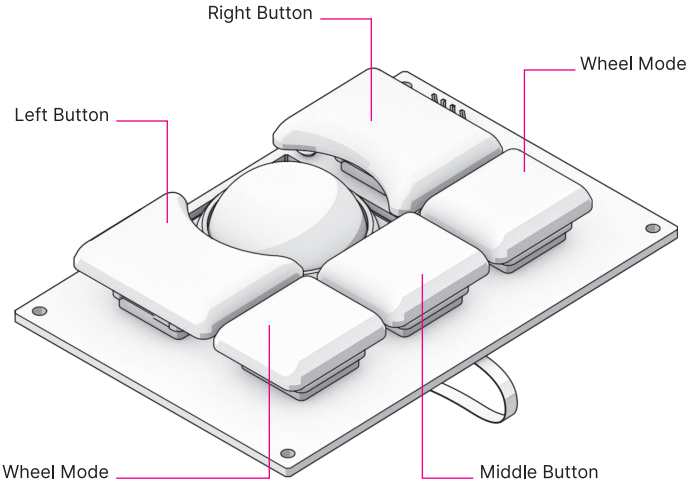


The keyboard has a built-in OLED display for interaction with the System Controller on the motherboard. You can highlight an option and scroll through the menu by using the ↑ and ↓ keys. To trigger the highlighted option, press *ENTER*. Alternatively, you can press the shortcut key that is displayed on the right hand side of each menu option. For example, to show the Battery Status, press *B* when the menu is active. To leave the menu, press *ESC*.



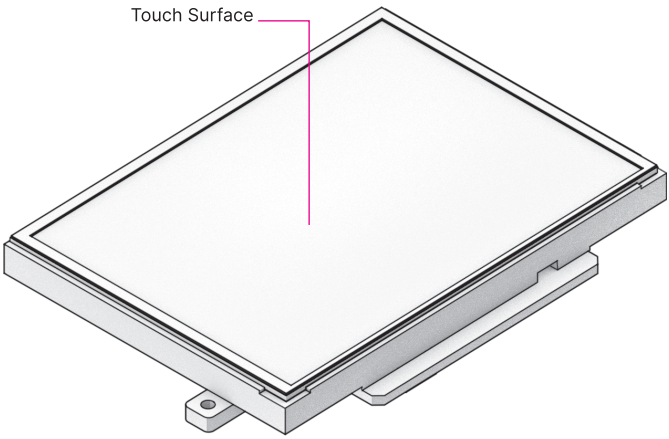
You can see detailed battery information including the estimated total charge percentage on the Battery Status screen reachable through the OLED menu. Each cell icon corresponds to one of the eight battery cells. The leftmost group of four icons represent the battery pack on the left side of the device, and the top icon in each group represents the leftmost cell in each pack—assuming you look at MNT Reform when flipped on its back and the battery closer towards you.

4.3 Trackball



The trackball works like a three-button mouse. Rolling the ball will move the cursor in the same direction. In addition to the standard three mouse buttons (left, middle, right), the trackball also has two *Wheel Mode* buttons. Holding down either while moving the ball up and down will scroll the currently focused content.

4.4 Trackpad



The trackpad senses the touch of your fingers. Unlike the trackball, it does not have any moving parts or buttons. Slide one finger across to move the cursor. Tapping with one finger acts like a left mouse button click. Sliding two fingers vertically allows you to scroll (like a mouse wheel). Tapping with two fingers performs a right click. To click and drag, i.e. to select text or drag and drop icons, use three fingers. Tapping three fingers is equivalent to a middle click.

Chapter 5

Linux Basics

5.1 The Console and Shell

With the provided SD card inserted, MNT Reform will boot to a Linux console, which is a pure text interface (opposed to a graphical windowing environment). This is so that you have a chance to learn about the lowest level of interaction with the operating system before moving on to more fully featured desktops. If something goes wrong, you can always go back to this level and fix things—if you know a few basics of Linux administration.

After logging in on the console, you are in control of a **shell**. The default shell is called `bash`[1], but there are many other shells available. You can use the shell to type in commands for your computer to execute, but also to write programs (scripts) that combine commands to do more complex tasks. For example, this handbook is generated by a `bash` script combining a few text and graphics related tools.

This chapter will introduce you to the basics of exploring and administering your MNT Reform system using the shell first and then a graphical desktop. Even on a desktop you will find

[1] The "GNU Bourne-Again Shell".

yourself launching shells to quickly perform tasks all the time. It is worth to invest the time to learn these basics, because you will be able to troubleshoot most problems by yourself, rather than relying only on graphical user interfaces that—while convenient—can obscure the system that lies beneath.

5.2 Set a Root Password

The most powerful user in the system is `root`. When logged in as `root`, you can modify but also destroy any file in the system. To prevent others from logging in as `root`, you should protect the account with a password. In the shell, you execute all commands by typing them in and pressing *ENTER*. To set your password, execute this command:

```
passwd
```

The `passwd` command will ask you for a new password two times, but will not display it while typing (so it cannot be gleaned by onlookers).

During normal Linux usage you will rarely want to be `root`—only when performing changes to the system configuration, which includes adding or removing users or software and controlling background services. Instead, you should create a less privileged user account for yourself.

5.3 Create a New User and Password

In order to add a new user account to the system, log in as `root` (you already have) and execute the `adduser` command (this will add a new user named `kim`, and add a new home directory for `kim` at `/home/kim`):

```
adduser kim
```

The `adduser` command will ask you for a password and a few questions that you can skip by just pressing *ENTER*.

If you want to change the password for the user `kim` later, you can use the `passwd` command as before:

```
passwd kim
```

5.4 Logging In and Out

You can log out by pressing *CTRL+D*. Alternatively, you can type `exit`.

When logged out, you will see the login prompt. Enter the username that you added in the previous step and press *ENTER*. Next, enter your password (it is not displayed). Press *ENTER* to complete the login.

5.5 Sudo

To make bigger changes to the system you will often need to use a command that requires `root` (superuser) privileges. Logging out of your user account just to log back in as `root` is inconvenient. Instead, you can temporarily become `root` by either switching to it as `su` (switch user) or give your regular user account `sudo` privileges[2].

Sudo allows you to use a command as `root` by typing `sudo <COMMAND>`. To add your user to the `sudo` group, first log out and login as `root`. Then you can execute the following command:

```
usermod -a -G sudo kim
```

(Substitute your username for `kim` here).

The `-a` flag means "Append the user to the group", while the `-G` option specifies the name of the group you want to add the user to: `sudo`.

[2] `sudo` means "switch user and do".

Log out and login as your regular user again. From now on, you can execute commands which require root privileges using `sudo`. For example, to shut down your computer safely before turning it off, you can type:

```
sudo shutdown now
```

5.6 File System

Your system's file storage is organized in a tree of directories. To move around in it, you use the `cd` command to change the current directory. The top of the hierarchy is called root (not to be confused with the superuser of the same name), but written as the symbol `/`. To go to the root directory, enter:

```
cd /
```

To see what's here, use the `ls` (list) command:

```
ls
```

If you want to know more details, such as the modification times and permissions of files, use:

```
ls -l
```

You can also add the flag `-h` to get "human readable" file sizes instead of the raw number of bytes:

```
ls -lh
```

There are two virtual files in every directory, called ".." (two dots) and "." (one dot). The single "." means "here" (i.e. the current directory), and you can use it if you ever want to specify the current directory explicitly. For example, if you want to copy the file `/tmp/myfile` to the current directory, you can type:

```
cp /tmp/myfile .
```

To go to the parent directory, use:

```
cd ..
```

Commands like `ls` have many options. To learn about them, you can read the built-in manual pages:

```
man ls
```

With `man` you can learn more about any command. You should make yourself familiar with the most important commands like `cp` (copy), `mv` (move), `rm` (remove), `mkdir` (make directory), `mount` and `ln` (link). Armed with this knowledge, you will be able to navigate any UNIX-like system, not only Linux.

5.6.1 Filesystem Hierarchy

When you issued `ls` at the top of the filesystem (`/`) before, you might have asked yourself what the purpose of all the directories there are.

/	Top ("root") of the filesystem
/bin	Essential commands ("binaries"), such as `ls`, `cp`
/sbin	Commands usually only used by `root`
/lib	Libraries (common code shared between binaries)
/usr	Files used by (non-essential) software
/boot	Boot loader related files (like Linux kernel[3])
/etc	System configuration files
/home	Home directories of user accounts
/root	Special home directory for `root`
/mnt	A place to mount other filesystems
/media	Another place to mount filesystems
/proc	Live information about processes
/sys	More live information from the kernel
/dev	Device files providing access to hardware
/run	Temporary files related to background services
/tmp	Temporary files—deleted on restarts
/srv	Files used by servers such as web servers

A good way to explore files and directories that take up disk space is using the `ncdu` program. It calculates the size of each

[3] The kernel is the privileged core of the operating system.

(sub)directory and allows you to browse your filesystem and even delete unwanted files (you should only do this in your home directory, though):

```
ncdu /
```

5.6.2 Home Directory

If your username is `kim`, your home directory is located at `/home/kim`. There's a shortcut for your home directory using the tilde symbol `~`. To go to your home directory, you can type:

```
cd ~
```

If you list the contents of your home directory, you will see a number of directories with self-explanatory names, such as `Pictures`, `Music`, `Documents` and `Downloads`. The last one is used by web browsers to store downloaded files, for example. Feel free to create your own subdirectories in your home directory as needed.

5.6.3 Dot Files

Your home directory also contains a number of hidden files and directories called "dot files". Their names start with a dot (`.`) and for tidiness, are usually hidden. To see them, use the `-a` flag with `ls`:

```
ls -a
```

Often times, dot files contain your personal configuration for certain programs. Many programs collect configuration files in the `~/.config` subdirectory.

5.6.4 Permissions

As you are the owner of your home directory, your user account is allowed to modify any files and subdirectories contained in it. But you cannot change system configuration files

in `/etc` or delete a command in `/bin`, except if you're `root`. This is because of the ownership and permission settings on these files and directories.

If you list the contents of your home directory with `ls -l`, you will see your username twice in each row, after a cryptic-looking column of letters and dashes and a number:

```
drwxr-xr-x  4 kim kim 4096 Nov  2 20:52  Music
-rw-r--r--  1 kim kim    8 Jan  9 20:03  notes.txt
```

The letters and dashes at the beginning describe the **file mode bits** of the file or directory. A "d" at the beginning signifies a directory. The following 9 letters are three triplets describing "user" (owner), "group", and "all" **permissions**, in that order. "r" means read, "w" write and "x" execute. An "x" on a file means that this is an "executable", a program that can be run, or in the case of a directory, that it can be entered.

The first occurrence of a username in each row is the **owner** of the file or directory. The first triplet of mode bits on `notes.txt` tells you that you, the owner, can read and write but not execute this file (after all, it is just a text file).

The second occurrence of `kim` names the group `kim`, not the user. When you create a new user, the system also creates a group with the same name and only you as a member. You could add other users to your group to share files with them, for example. The second triplet of mode bits, `r--`, tells you that members of this group can only read your file, not change it.

Lastly, the third mode triplet (`r--` in this example) says that any other user logged into your system can read this file.

To change the mode bits of a file, you can use `chmod`. For example, to give nobody but yourself (assuming you're the owner) the permission to read and write the file `notes.txt`, execute:

```
chmod a=,u=rw notes.txt
```

This invocation first sets an empty list of modes for all users (`a=`) and then read and write modes for the user/owner (`u=rw`)

on the file.

To learn more about managing modes and ownership, be sure to read the `man` pages for `chmod`, `chown`, and `chgrp`.

5.6.5 Pipes

Linux features some advanced concepts that are central to the UNIX philosophy (Linux is a flavor of UNIX). One that you will often encounter is the pipe, symbolized by `|`. You can use pipes to feed the output of one program to the input of another program. For example, you can use the pager `less` to paginate the output of the kernel log:

```
dmesg | less
```

Or page through a long list of files:

```
ls -la ~/Downloads | less
```

You can also build more complex pipelines. The following command will output the last 5 lines containing the word "usb" in the kernel log:

```
dmesg | grep usb | tail -n 5
```

5.6.6 Links

If you list the contents of `/usr/lib` with `ls -l` you will see a number of files that point to another file with an arrow (->). This is because the file on the left hand side is a "symbolic link" to the "real" file on the right hand side. Symbolic links and "hard links" can be created using the `ln` command as a means to point to a file using another name. This can be useful to create shortcuts. Refer to the manual page with `man ln` to learn about the details of links.

5.6.7 Finding Files

If you don't remember where you put a file, or want to search a complex hierarchy of directories for something specific, you

can use `find`:

```
find -name "notes*"
```

This will display any file or subdirectory whose name starts with “notes” in the current directory. `man find` will reveal many more options for finding files.

The `rgrep` command will look for words in the content of a file:

```
rgrep --color spice
```

This will look for any occurrence of the word “spice” in files in the current directory and its subdirectories, and display each line in which the word was found, with the word itself highlighted.

5.6.8 Mount

The root directory `/` is actually a collection of filesystems “mounted” into one virtual filesystem. These can be located on different disks, media or even the network—or be purely virtual in the case of `/dev`, `/proc` or `/sys`.

For example, if you want to access files stored on a USB stick, you would first **mount** one of the filesystems contained on the USB stick into an empty directory called a **mount point**. This could be something like `/mnt` or `/media/usb-stick`. Usually, desktop environments can help you to automatically mount removable media, but it’s useful to know how to do the same process manually.

First, you need to find the **block device** of the media you want to mount. For this, you can use the command `lsblk`. An example (partial) `lsblk` output could be:

```
NAME          MAJ:MIN RM   SIZE RO TYPE  MOUNTPOINT
sda             8:0    1  28.9G  0 disk
  sda1          8:1    1  28.9G  0 part
```

Here, `sda1` is the block device of the first partition on the USB stick. If you are unsure which is the right device, you can is-

sue `dmesg -w` and then plug in the stick. You'll see something like this appear in the kernel log:

```
[...] sd 0:0:0:0: [sda] Attached SCSI removable disk
```

Which tells you that `sda` (or in your case, something else) is the block device you're looking for.

To mount the partition on the stick at `/mnt`, do:

```
sudo mount /dev/sda1 /mnt
```

If successful, this will—in UNIX tradition—output nothing, and you can find your files by navigating to `/mnt` with the usual commands.

Before unplugging your stick, you should **unmount** it. This makes sure any pending changes are written to the device (note that the command is `umount`, not "unmount"):

```
sudo umount /mnt
```

5.7 (Environment) Variables

As the shell is not only a command interpreter but also a programming environment, it supports **variables**. These are placeholder names that contain a value that can be changed at any time. For example, you could make a universal greeting command like this:

```
echo Hello, $name.
```

The output of this command changes depending on the value of the variable `$name`. To change the variable, do:

```
name=World
```

If you now execute the same `echo` line as before, you'll see this output:

```
Hello, World.
```

Variables are often used to define an **environment** for other programs. To see all so called environment variables, you can

use the `env` command. Among the output you will see some familiar things, for example:

```
HOME=/home/kim
PWD=/home
SHELL=/bin/bash
USER=kim
```

This means that another way to reach your home directory is `cd $HOME`, and another way to refer to your username is `$USER`. A critically important variable is `$PATH`, which is a list of directories (separated by ":") that the shell searches when looking for a command that you want it to execute. For example, when you type `ls`, your shell will only find `/bin/ls` if `/bin` is in your `$PATH` (which should always be the case).

5.8 Work with Text Files

Most system configuration is done via by editing text files.

The two most common text editors among Linux users are `vim` and `emacs`. Both of them have a steep learning curve, which can be rewarding to climb—but the standard Reform system also ships with a simpler editor more suited for beginners. This editor is called `micro`.

You can create, view, and edit files using the `micro` text editor. To edit a file in the current directory named `file.txt`, use:

```
micro file.txt
```

While in micro, you can use *CTRL+S* to save, *CTRL+Q* to quit, and *CTRL+G* to display a help menu.

5.9 Scripts

By now you know most of the ingredients to be able to write **shell scripts**: programs interpreted by the shell. By writing shell scripts, you can create your own commands to extend

the capabilities of your computer. Here is an example script that greets the user:

```
#!/bin/sh

day=$(date +%A)
echo Hello, $USER. Today is $day.
```

The first line of the script, called the "shebang" line is important to tell the operating system that this script is to be interpreted by the shell `/bin/sh`. Save the script to a file named `greet.sh`. Mark the file executable and execute it:

```
chmod a+x ./greet.sh
./greet.sh
```

You can learn more about programming the shell by reading its manual page `man sh`. The more advanced `bash` shell is documented in `man bash`.

5.10 What Is My Computer Doing?

You can check your RAM usage, CPU usage, and processes currently running by using `htop`:

```
htop
```

Hit F1 to display the built-in help screen.

You will see that there are a few processes running that you didn't start yourself. These are background processes, also called services, daemons, or units. They are controlled by `systemd`, the so-called "init system". It is the first program started by the Linux kernel, and it spawns all other programs including services. You can learn more about systemd by reading the manual page:

```
man systemd
```

The most important commands to manage systemd are `systemctl` and `journalctl`. Their manual pages are worth a look, too.

To see the list of known units and their status, you can use (press q to quit):

```
systemctl
```

To inspect a unit in more detail, you can pass its name to systemctl, for example:

```
systemctl status ssh
```

Instead of `status`, you can use verbs like `start`, `stop` or `restart` to control units.

The Linux kernel itself outputs a lot of diagnostic information at boot and when hardware changes (e.g. new devices are plugged in). To see the kernel log, you can (as superuser) use:

```
sudo dmesg -H
```

5.11 Inspect Hardware

The following commands are useful to inspect devices connected internally or externally:

Command	Description
`lsblk`	List block devices (storage).
`lsusb`	List USB devices.
`lspci`	List devices connected to PCIe ports.
`lscpu`	Get information about the processors.
`free -h`	Get information about system memory.

To view of a structured list of all clock frequencies in use in the SoC:

```
sudo cat /sys/kernel/debug/clk/clk_summary
```

To see a table of interrupts:

```
sudo cat /proc/interrupts
```

5.12 Clock

The motherboard of MNT Reform has a battery-backed real-time clock chip (PCF8523T, U5). This chip saves the date and time even if your system is shut down or loses power. You can interact (as `root`) with the clock using the `hwclock` tool. Review `man hwclock` for the details.

5.13 Network

MNT Reform has a built-in Gigabit Ethernet (1 GbE) port for networking. Additionally, you can install a Wi-Fi card in the mPCIe slot.

Usually, you want to use a convenient management tool like `connman-gtk` (preinstalled) or `network-manager` (available as Debian package) to easily manage your network connections. If you want to low-level troubleshoot, you can use the `ip` tool:

Command	Meaning
`ip addr`	Show the status of the network interfaces[4].
`ip route`	Show the network routing table.

You can trigger an automatic configuration of an interface via DHCP by executing `dhclient eth0`, and you can change the DNS servers by editing the file `/etc/resolv.conf`.

To connect to a remote computer via a secure shell connection, try `ssh` followed by the IP address of the computer you want to connect to. If you want to login to MNT Reform over the network, you can enable the secure shell daemon service as follows:

```
sudo systemctl enable sshd
```

You can then login to MNT Reform from another computer on your local network by executing:

[4] `eth0` is the built-in Ethernet; `wlp1s0` is a WiFi interface.

```
ssh kim@192.168.1.242
```

Substitute your username for `kim` and your IP address for `192.168.1.242`. You can find your IP address by looking for the `inet` entries in the output of the `ip addr` command.

Before using SSH functionality, you should generate a public/private key pair by executing `ssh-keygen`.

5.14 External Display

MNT Reform has an HDMI connector that has different functions depending on the installed CPU module. When using the i.MX8MQ module, you can connect an external HDMI display to this port.

i.MX8MQ has two display engines, LCDIF and DCSS. In the default configuration, DCSS powers the internal display. If you want to use an external display, DCSS has to power HDMI instead. The internal display can then either be turned off or powered by LCDIF. At the time of writing, there is a limitation in i.MX8MQ that prevents the use of LCDIF together with PCIe devices like NVMe storage—the LCDIF output will glitch when the disk is accessed over PCIe. This means that if you want to use a dual display setup with i.MX8MQ and MNT Reform, you have to run your system from eMMC or SD card instead. You can also use external USB3.0 based storage.

The HDMI controller of i.MX8MQ requires a piece of binary firmware that is signed by NXP and loaded by the CPU into the HDMI controller as part of the U-Boot bootloader. If you don't want to use HDMI, you can download an alternative version of U-Boot with the HDMI firmware stripped out at the MNT Reform website.

The MNT Reform system software comes with a script to select your desired display output mode and reboot:

```
reform-display-config
```

Executing the script without any parameters will show you the available options.

5.15 Shutdown

Before turning off MNT Reform, you should shut down the system cleanly by executing:

```
shutdown -h now
```

In the GNOME desktop environment, you can do this—without typing commands—from the menu that appears when you click the power button in the right corner of bar on top of the screen.

In the Debian system shipped with MNT Reform, the shutdown process will ask the System Controller to turn off the power. The OLED display will then show an animation of a disappearing MNT Research logo. In case you have to turn off the power manually (for example if the system is unresponsive or you are using an alternative OS), press *Circle* and then *0* (zero).

5.16 Standby

The i.MX8MQ system-on-chip can enter a low power standby mode. At the time of writing, we consider this function experimental and are still optimizing it. Don't rely on the stability of this function and always save your work to disk regardless. In our tests, the power consumption in standby mode is roughly halved compared to the normal working mode.

To enter standby mode, execute the provided `reform-standby` script:

```
reform-standby
```

To make the system wake up from standby, select the "Wake" command from the keyboard OLED menu.

5.17 Install and Remove Software

The Debian GNU/Linux distribution has access to a large number of software packages. No matter which desktop you use, these are centrally managed by "apt", the package manager. Generally, on a Linux system you rarely download executables from the internet and launch them. Instead, you can cleanly install and remove software packages by using the package manager. Apt also has the ability to search for keywords (or regular expression patterns):

```
apt search browser
```

This will list all packages in the apt cache that contain the keyword "browser". To refresh apt's list of packages available at the online Debian "repository" (the library of packages), use the following command:

```
sudo apt update
```

If you have found a package you would like to install:

```
sudo apt install firefox
```

To remove (uninstall) the package from your system:

```
sudo apt remove firefox
```

To explore all of apt's functionality, read the man pages for `apt` and `apt-cache`. If you are more comfortable with a graphical user interface for managing apt packages, you can install `synaptic`:

```
sudo apt install synaptic
```

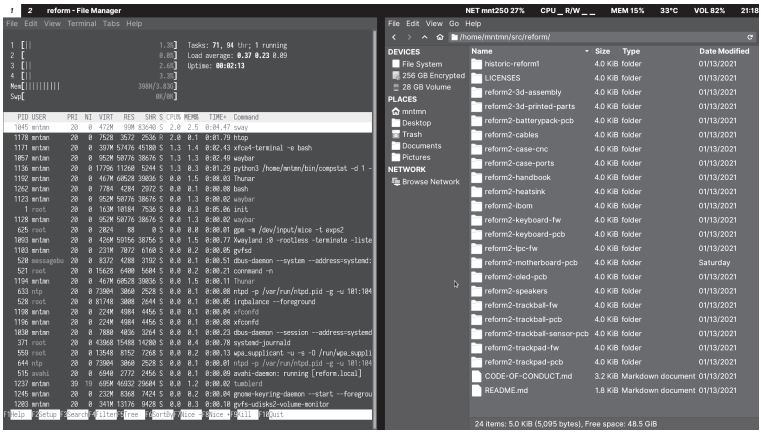
Chapter 6

Graphical Desktops

MNT Reform ships with two graphical environments ("desktops") on the SD card. The Debian distribution, which the system on the SD card is based on, has a number of additional desktops in its package manager (See section 5.16, "Install/Remove Software").

1. The **Sway** compositor emphasizes the concept of "tiling". This means that normally, windows don't overlap, but instead the screen space is automatically divided to make space for new windows. Sway consumes minimal system resources, but relies heavily on keyboard shortcuts, which makes it harder to learn.
2. The **GNOME** desktop features classic overlapping windows and a modern look. It is easy to learn and use with mouse/trackball/trackpad pointing and clicking, but requires more system resources.

6.1 Sway



You can start sway from the command line by executing the `sway` command:

```
sway
```

From now on, you can start a new terminal window by holding down the *SUPER*[1] key and pressing the *ENTER* key once (*SUPER+ENTER*).

6.1.1 Tiling

When you press *SUPER+ENTER* multiple times to open several terminals, you'll notice that your currently open windows will be resized to accommodate for the new window. You can switch between these windows by holding the *SUPER* key and pressing the cursor (arrow) keys in the desired direction.

If you keep adding windows, they will continuously shrink horizontally, but if you would rather have a window split vertically, you can. Use these shortcuts for deciding:

SUPER+H	Split window horizontally

[1] *SUPER* is the key with the MNT Research logo next to the *HYPER* key.

SUPER+V	Split window vertically

Note that the window is not split instantaneously. You're just telling Sway "The next time I create a window, put it below/beside my current window."

You may also use *SUPER+W* to tell Sway to use tabs. You can switch your tab using the same shortcuts for switching between windows.

You can use *SUPER+ESC* to close the currently selected window.

6.1.2 Workspaces

You can change your active workspace with the number keys, for example:

SUPER+2	Go to workspace 2
SUPER+1	Go back to workspace 1
SUPER+SHIFT+5	Move active window to workspace 5

You can open different spaces for different programs. For example, you might want to put your code-editing programs in workspace 1, a web browser in workspace 2, and some instant messaging programs in workspace 3.

6.1.3 Launching Applications

Reform's sway configuration includes "rofi", a popup menu for launching an application by typing a part of its name. Press *SUPER+D* to open the menu. Over time, rofi will remember the applications you regularly launch and list them in the initial menu.

6.1.4 Waybar

On MNT Reform, Sway comes with an information bar at the top of the screen called "Waybar". In the left corner, Waybar shows the active workspaces as tabs. Instead of using keyboard combinations, you can click on a tab to activate the corresponding workspace. Next to the workspaces, Waybar shows the title of the window that is currently in focus.

In the right corner, Waybar shows the following information (in this order):

Field	Action on Click
Network	Network Configuration (`connman-gtk`)
CPU/Disk	System Monitor (`gnome-system-monitor`)
Memory Usage	—
CPU Temperature	—
Volume	Volume Control (`pavucontrol`)
Battery Gauge	—
Clock	Toggles between time and date

6.1.5 Display Brightness

You can set the display's brightness using the `brightnessctl` command or, more conveniently, use one of these keyboard shortcuts:

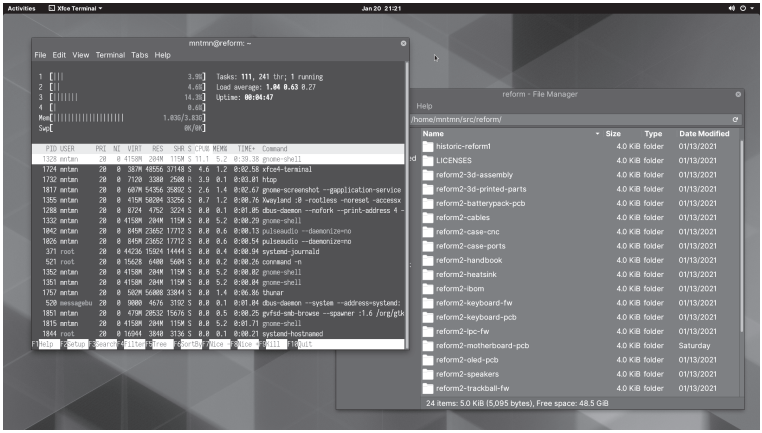
SUPER+F1	Decrease display brightness
SUPER+F2	Increase display brightness

6.1.6 Config File

You can tailor Sway's behavior and keyboard shortcuts by editing the file `~/.config/sway/config`.

All configuration options are documented in the Sway Wiki: `https://github.com/swaywm/sway/wiki`

6.2 GNOME



Launch the GNOME desktop from the Linux console by typing:

```
gnome
```

After a while, the label “Activities” will appear in the top-left corner of the screen. Click this label to reveal the Activities overview. Alternatively, you can press the *SUPER* key to open this overview. From here, you can launch applications by typing their name. You can drag and drop applications that you commonly use into the “dock” on the left. Applications that are already running are displayed in the dock, too. Clicking on them will bring them to the foreground.

GNOME supports a range of keyboard shortcuts to speed up working with the desktop:

SUPER	Open Activities
SUPER+TAB	Go to next window
SUPER+SHIFT+TAB	Go to previous window
CTRL+ALT+T	Launch a terminal
SUPER+PGUP	Workspace above
SUPER+PGDN	Workspace below

GNOME displays system status icons in the top-right corner of the screen. You can click these icons to access network configuration, see the battery status and log out or shut down the computer.

To learn more about the details of the GNOME desktop and its software suite, visit: `https://help.gnome.org`

Chapter 7

Preinstalled Software

MNT Reform can run most Linux applications that are available for 64bit ARM-based computers (also called aarch64 or arm64). We tested and included some of the best free and open source applications with the default system.

7.1 Web & Communications

Firefox Mozilla's open-source web browser.

Command: `firefox`

`https://www.mozilla.org/en-US/firefox`

Chromium The open-source variant of Google's Chrome web browser.

Command: `chromium`

`https://www.chromium.org`

Evolution This graphical email client includes many features for organizing your inbox. Additionally, it includes a calendar, notes, and an address book.

Command: `evolution`

`https://wiki.gnome.org/Apps/Evolution`

Linphone A voice-over-IP (SIP) client which has support across all major platforms. You can use it for voice and video calls, along with messaging.

Command: `linphone`

`https://www.linphone.org`

7.2 Productivity & Creativity

LibreOffice LibreOffice is your one-stop shop for common productivity tasks. Includes a word processor (Writer), spreadsheet (Calc), presentation (Impress), diagramming (Draw) and more.

Command: `libreoffice`

`https://www.libreoffice.org`

GIMP The "GNU image manipulation program" is a complete image editing and photo manipulation tool.

Command: `gimp`

`https://www.gimp.org`

Inkscape Create vector (SVG) based artwork including text.

Command: `inkscape`

`https://inkscape.org`

FreeCAD Create and view 3D models of objects, buildings, and complex mechanisms. You can use FreeCAD to inspect the mechanical design files of MNT Reform.

Command: `freecad`

`https://www.freecadweb.org`

KiCAD Design electronic circuit schematics and printed circuit boards. You can use KiCAD to browse the electronics design files of MNT Reform.

Command: `kicad`

`https://kicad.org`

Blender Create and render 3D objects and scenes. MNT Reform ships with a custom build of Blender 2.79b, the last version that works with the Vivante GC7000L GPU built into the i.MX8MQ processor.

Command: `blender`

`https://www.blender.org`

Ardour 6 Record, edit and mix multitrack audio and MIDI.

Command: `ardour`

`https://ardour.org`

Evince View PDFs and other documents.

Command: `evince`

`https://wiki.gnome.org/Apps/Evince`

Sxiv A simple and fast image viewer.

Command: `sxiv`

`https://github.com/muennich/sxiv/`

7.3 Games

Neverball This 3D game lets you guide a ball through 24 challenging levels.

Command: `neverball`

`https://neverball.org`

ScummVM Play classic adventure games on Linux using this utility. Copyrighted games may be purchased on GoG.com, although a handful of games are freeware.

Command: `scummvm`

`https://www.scummvm.org`

Minetest_Game An 3D block-based open-world game focused on exploration, resource gathering, and construction.

Command: `minetest`

`http://www.minetest.net`

VICE Commodore 64 (and related) system emulator

Command: `x64`, `x128` etc.

`https://vice-emu.sourceforge.io`

Amiberry Commodore Amiga system emulator

Command: `amiberry`

`https://blitterstudio.com/amiberry/`

DOSBox MS-DOS PC system emulator

Command: `dosbox`

`https://www.dosbox.com`

7.4 Tools

Thunar Lightweight file manager.

Command: `thunar`

Sway keyboard shortcut: *SUPER+T*

`https://docs.xfce.org/xfce/thunar/start`

Xfce4 Terminal A terminal emulator with convenient features like tabs and custom themes.

Command: `xfce4-terminal`

Sway keyboard shortcut: *SUPER+ENTER*

`https://docs.xfce.org/apps/terminal/start`

Grim & Slurp Grim is a wayland-based screen shot tool, and Slurp lets you select the region of the screen you want to capture.

Command: `grim -g "$(slurp)"`

Sway keyboard shortcut: *SUPER+SHIFT+X*

`https://wayland.emersion.fr/grim`

Emacs One of the popular Linux text editing environments.

Command: `emacs` (Exit with *CTRL+X* followed by *CTRL+C*)

`https://www.gnu.org/software/emacs`

Vim The other major open text editor.

Command: `vim` (Exit by typing `:q` followed by *ENTER*)

`https://www.vim.org`

Htop A terminal-based look at system processes, CPU and memory usage.

Command: `htop`

`https://htop.dev`

MPV A versatile, terminal-based media player.

Command: `mpv a-movie-file.mp4`

`https://mpv.io`

GNOME Disks Partition, format, and manage internal and external disks.

Command: `gnome-disks`

`https://wiki.gnome.org/Apps/Disks`

NCurses Disk Usage Terminal-based disk usage analysis utility.

Command: `ncdu`

`https://dev.yorhel.nl/ncdu`

Wayland Event Viewer Useful when debugging input devices under wayland-based compositors such as Sway.

Command: `wev`

`https://git.sr.ht/~sircmpwn/wev`

Wayvnc Access your MNT Reform desktop remotely from VNC clients on other platforms using this server application.

Command: `wayvnc`

`https://github.com/any1/wayvnc`

Wf-Recorder Record MP4 video of your desktop with this program.

Command: `wf-recorder` (Stop with *CTRL+C*. The resulting video is named “recording.mp4”)

`https://github.com/ammen99/wf-recorder`

Chapter 8

Software Development

If you want to develop software for MNT Reform, there are a few things to consider. You can write software targeting the main CPU or modify firmware for the system controller and input devices. All of these have different architectures. Keep in mind that the main CPU is modular, though targeting 64-bit ARM (aarch64) is a good bet until upgrades with other architectures become available (for example, RISC-V). This chapter covers development for the default i.MX8MQ module and some general best practices to keep your software portable.

8.1 i.MX8MQ: CPU

The i.MX8MQ SoC has the following CPU cores:

- 4x Cortex-A53 at 1.5 GHz
- 1x Cortex-M4F at 266 MHz

At the time of writing, the integration of the M4 core into mainline Linux is not production-ready.

Linux (or another operating system) runs on the four Cortex-A53 cores. Cortex-A53 is a power efficient in-order core.

This makes it less performant but also immune to certain security weaknesses of out-of-order processors, for example Meltdown.[1]

Optimizing your program to make use of multiple cores versus relying on single-core performance will pay off on MNT Reform. Also, make use of SIMD (NEON) optimizations. Try to keep memory usage and UI effects minimal. If your application runs well on MNT Reform, it will run well on a broad range of older PC hardware, but also on single board computers such as the Raspberry Pi.

8.2 Binary (In)compatibility

A popular architecture for PCs and laptops is x86_64 (aka amd64). Binaries compiled for this architecture are incompatible with ARM processors. If you want to use binary software (or dependencies/modules), you have to make sure that these are built for aarch64. The vast majority of open-source software is available for aarch64, but there can be subtle problems when x86 is implicitly expected, for example:

- Optimizations written in assembler (machine code), targeting specific SIMD/vector instructions
- JIT (just-in-time) compilers
- Docker images built for x86_64

Generally, instead of using inline assembler or targeting a single architecture directly, use cross-platform libraries and code-emitting backends. Examples are LLVM and GLM.

8.3 i.MX8MQ: GPU

The embedded GPU in i.MX8MQ is a Vivante GC7000L. It can theoretically support OpenGL ES 3.1, but the open-source Etnaviv drivers (included in the Mesa project) don't support this

[1] See `https://meltdownattack.com`

level at the time of writing. The safest target for 3D graphics is OpenGL ES 2.0. Desktop OpenGL 2.1 API support is good, too. There is no support for Vulkan nor OpenCL yet.

If you want to make sure your 3D application or game works well, target:

- OpenGL ES 2.0, GLSL ES 1.00 (recommended)
- OpenGL 2.1, GLSL 1.20
- WebGL 1.0

Tested and recommended libraries/frameworks are:

- SDL 2
- GTK 3/GTK 4
- Qt 5/Qt 6
- Dear Imgui
- Godot Engine (targeting GL ES 2.0)
- Text-based interfaces (TUIs)

Wayland works better than Xorg directly, but Xorg applications work well on top of Wayland through Xwayland or Xephyr.

8.4 i.MX8MQ: VPU

i.MX8MQ includes hardware accelerators for decoding H.264, H.265, VP8 and VP9. At time of writing, support for H.264 decoder ("Hantro") just landed in the Linux kernel with fully open source drivers, accessible through the gstreamer library.

8.5 WM8960 Audio

The audio output defaults to 48KHz stereo. You can also sample from one microphone input channel (part of the CTIA stan-

dard TRRS headset jack) or the stereo Line In header on the motherboard (J21).

You can use the ALSA API directly or higher level APIs such as PulseAudio, Jack or OpenAL.

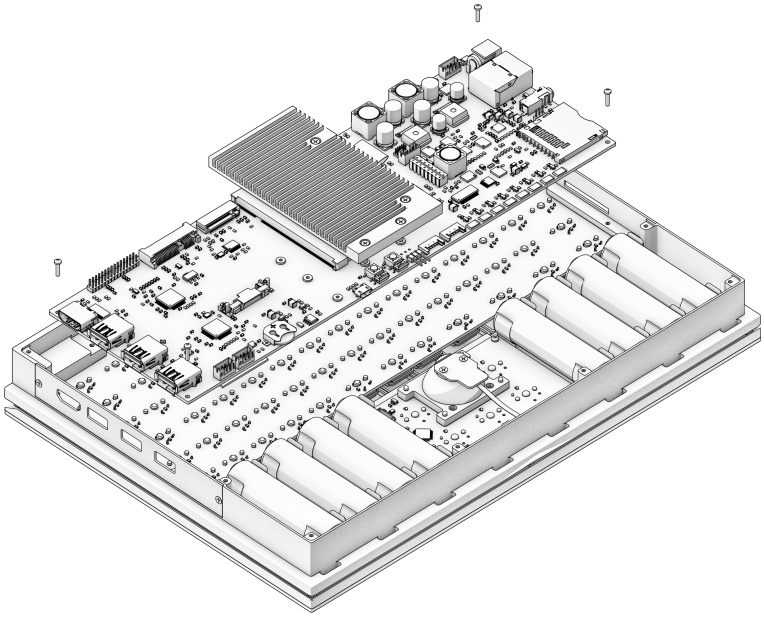
8.6 Languages

While you can easily write programs in C and C++—and the Linux kernel and most layers on top of it are still written in C—you can also use Rust, Go, SBCL, Haskell, Java or scripting languages such as JavaScript, Python, Ruby on MNT Reform. All of these have first-class aarch64 support.

Applications that use web browser engines (such as Electron) can disappoint in terms of performance on MNT Reform. Programs using native toolkits will run faster, use less memory and provide a better user experience.

Chapter 9

Parts



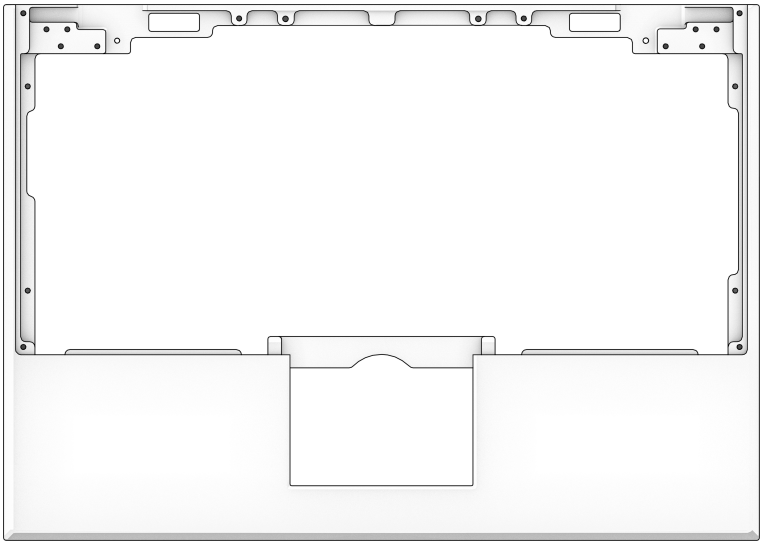
9.1 Case Parts

The case consists of the following 5 parts. All parts except the Bottom Plate are milled from sand-blasted and anodized 6061 aluminum.

1. **Main Box:** the chassis of MNT Reform. All PCBs (printed circuit boards) are attached to it via screws: The keyboard from the top and motherboard, trackball/trackpad, and battery boards from the bottom. The lower half of the hinges and the system controller OLED PCB are mounted from the top as well.
2. **Keyboard Frame:** a thin rectangle that covers the sides of the keyboard and the system controller OLED
3. **Screen Back:** housing the display and upper half of hinges
4. **Screen Front:** housing speakers and providing display bezel
5. **Bottom Plate:** the clear acrylic plate that closes the laptop from the bottom

For easy (dis)assembly, Reform uses M2 screws with Phillips-head everywhere—with one exception: M4×5 on the top half of the hinges.

9.1.1 Main Box

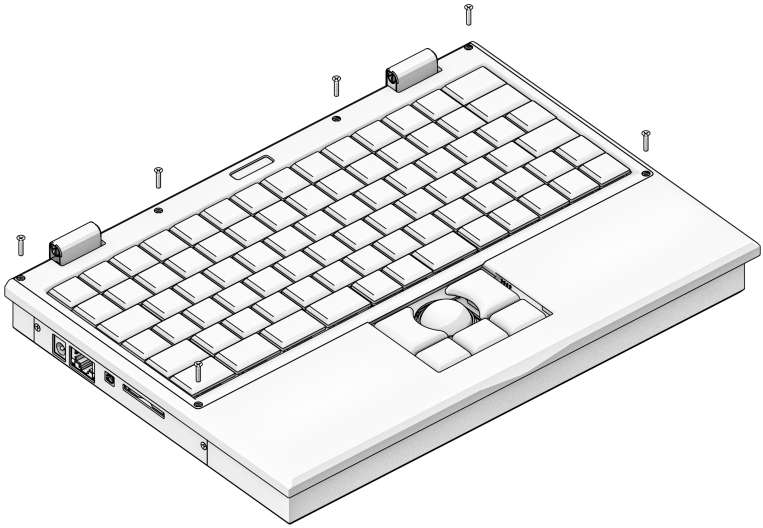


The Main Box houses most of the electronics:

- Motherboard, exposing ports through openings on the left and right
- Two LiFePO4 battery packs, connecting to the motherboard via Molex PicoLock cables
- Keyboard, connecting to the motherboard via two JST-PH cables
- OLED display, connecting to the keyboard via a 4-pin 1mm pitch flex cable
- Trackball or Trackpad, connecting to the motherboard via one JST-PH cable

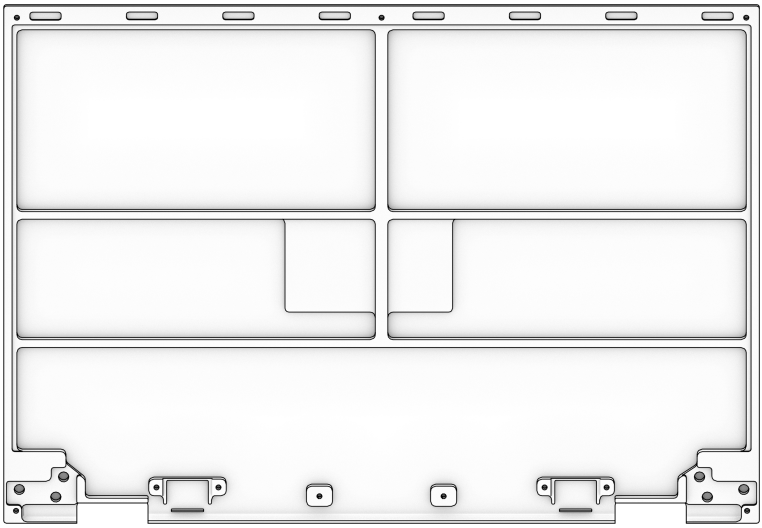
The Main Box features four neodymium bar magnets inserted into slots below the front edge. These match with their counterparts in the Screen Front.

9.1.2 Keyboard Frame



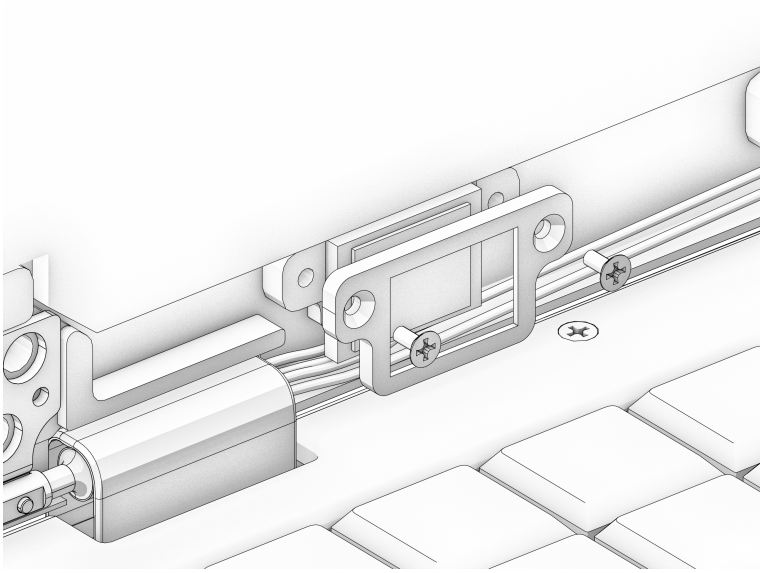
The Keyboard Frame is inserted into the Main Box to close it from the top. It has four tabs on the front that must be inserted first. The frame is mounted with six black M2×5 countersunk screws.

9.1.3 Screen Back



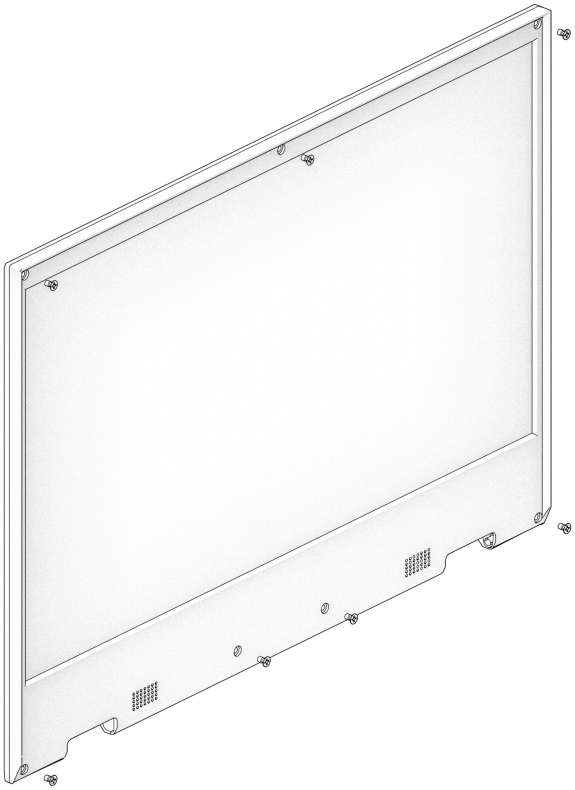
The eDP display panel rests in this case part. The left and right hinges are mounted in the bottom left and right corners with three M4×5 countersunk screws each. Note that the hinge labeled “SMS-ZZ-219-L” goes on the right side, and the hinge labeled “SMS-ZZ-219-R” goes on the left side. The other half of each hinge is mounted to the Main Box with four M2×6 countersunk screws.

Four neodymium magnets are mounted along the top edge of the Screen Back. These, together with their counterparts in the Main Box, hold the laptop shut when closed.



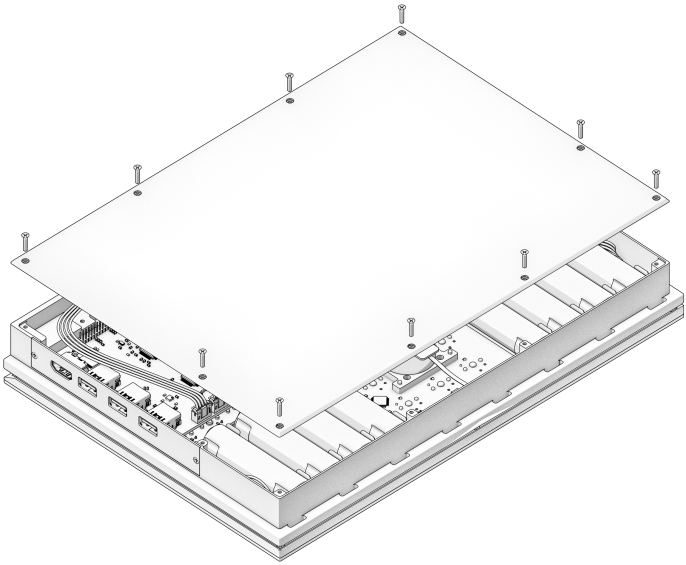
The stereo speakers are mounted below the display and secured with the speaker holders. Each holder is mounted with two black M2×5 countersunk screws. Both speaker and display cable are fed through a cutout in the hinge and into the Main Box.

9.1.4 Screen Front



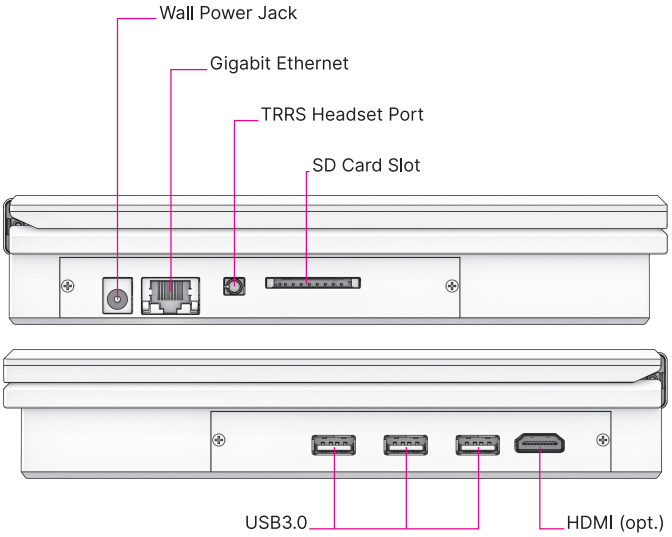
This part serves as a bezel for the display. It is mounted with seven black M2×5 countersunk screws to the Screen Back.

9.1.5 Bottom Plate



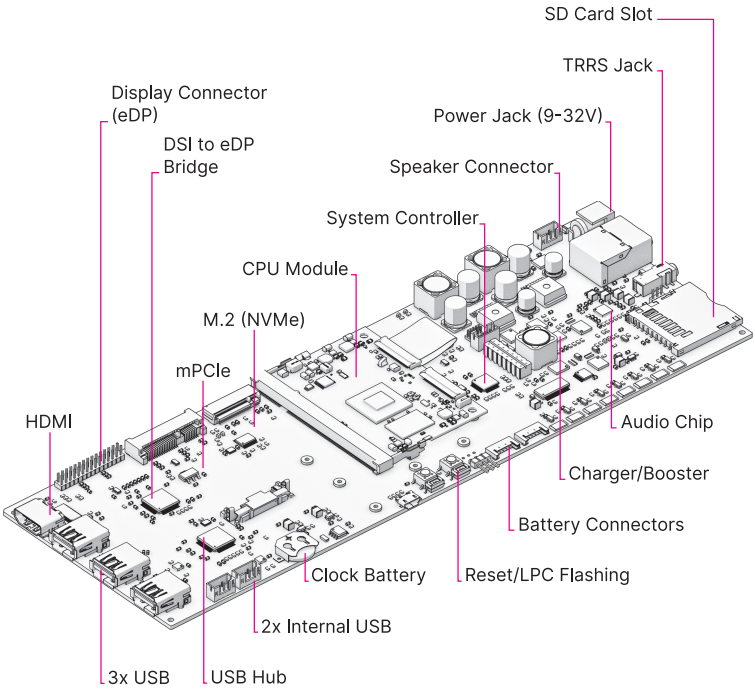
The Bottom Plate closes the Main Box from the bottom with ten M2×6 countersunk screws.

9.1.6 Port Covers



The Port Covers are two pieces of laser cut acrylic (1mm thick) that cover the side openings of the Main Box (mounted with two black M2×5 screws each). You can exchange these to fit a future motherboard or an expansion that requires a different port layout.

9.2 Motherboard



The Motherboard spans the inner width of the device and has outward-facing ports on both sides. It is mounted to the Main Box with four M2×4 pan head screws. The Motherboard has the following main features:

- **Power system:** based on the LTC4020 buck/boost converter, it regulates charging of the LiFePO4 batteries and seamlessly switches between wall and battery power.
- **System controller:** coupled to the power system, an NXP LPC11U24 Cortex-M0 MCU controls an analog monitor chip for the eight battery cells as well as the charger. It is connected to the CPU module via SPI, and has GPIO

lines to the main power rail switchers in the system. It has a UART (SYSCTL) that the keyboard can talk to directly for issuing power on/off commands and battery status queries.

- **DSI to eDP bridge:** The SN65DSI86 chip converts the MIPI-DSI output from the CPU module to an embedded DisplayPort (eDP) signal that the display panel can understand.
- **USB 3.0 hub:** The CPU module has two USB 3.0 controllers. To provide for a total of five USB ports (two internal and three external), there is a TUSB8041 USB hub chip on the motherboard that provides the extra ports. USB load switches on each external port protect the system from too much current draw.
- **Sound chip:** A Wolfson/Cirrus WM8960 audio DAC (digital-to-analog converter)/amplifier interfaces to the headphone/microphone jack and powers two speakers housed below the main display.
- **mPCIe slot:** An mPCIe connector that you can use for expansions like a Wi-Fi card.
- **M.2 slot:** An NGFF slot (Key M) that can house an NVMe SSD (solid state disk).

9.2.1 System Controller

Independent from the main processor module, a low-power processor sits on MNT Reform's motherboard. The NXP LPC11U24 is a 32-bit ARM Cortex-M0 processor that uses very little power and is always on as long as there is battery or wall power present. We call this processor the System Controller.

The System Controller runs a program in an endless loop that has the following jobs:

- Powering the individual voltage rails of the system on and off (including the main processor's power and the

mPCIe slot's power, to implement a WiFi killswitch, for example)

- Hard resetting the main processor on demand
- Monitoring the voltage of each battery cell
- Balancing battery cells. If a cell is overvolted, charging is halted and the overvolted cells are discharged until they are back to a nominal voltage
- Turning off the system if battery cells are undervolted
- Reporting total current flowing in and out of the batteries
- Turning charge current on or off

Your main way of communicating with the System Controller is with the Keyboard. The Keyboard has, aside from its USB connection to the main processor, a second serial (UART) connection/cable to the motherboard's SYSCTL port. A 57600 bps connection is always established between the Keyboard and the System Controller.

It accepts commands in the form of a single letter followed by return. A command can also be prefixed with a single argument, a positive integer of up to 4 digits. The most important commands are:

- *1p*: Turn the computer on
- *0p*: Turn the computer off
- *a*: Get current flowing into/out of batteries in mA
- *v*: Get cell voltage statistics
- *V*: Get system voltage at point of combined battery input/output
- *s*: Get System Controller state (a message string)
- *g*: Get estimated "fuel gauge" of batteries (percentage)

The individual cell voltages are measured by the Battery Monitor LTC6803IG-4#PBF and reported via SPI to the System

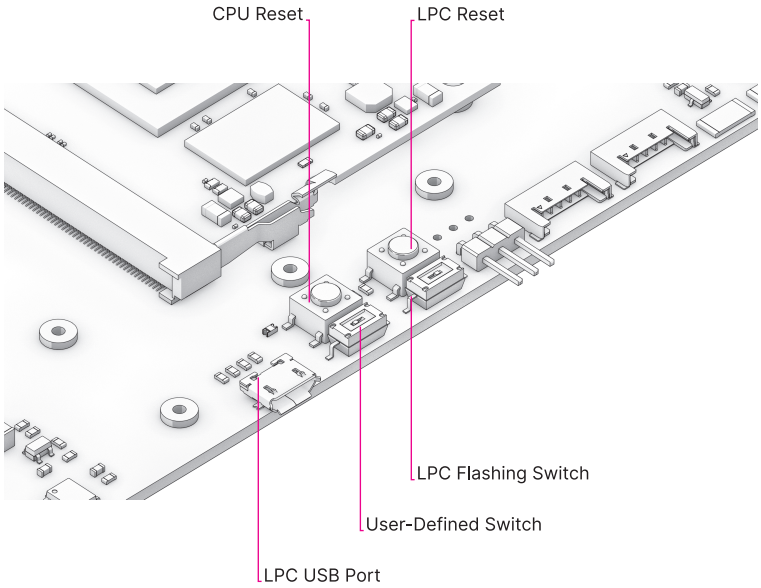
Controller. The total voltage and current are measured by the INA260 chip and reported via I²C.

To understand the available commands in more detail, you can take a look at the System Controller's `handle_commands()` function.

The System Controller is permanently connected to the main processor's UART2 (`/dev/ttymxc2` in Linux). You can monitor the raw output of the System Controller going to the Keyboard by connecting a terminal such as GNU Screen to the internal serial port UART2:

```
screen /dev/ttymxc2 57600
```

9.2.2 Flashing the Firmware



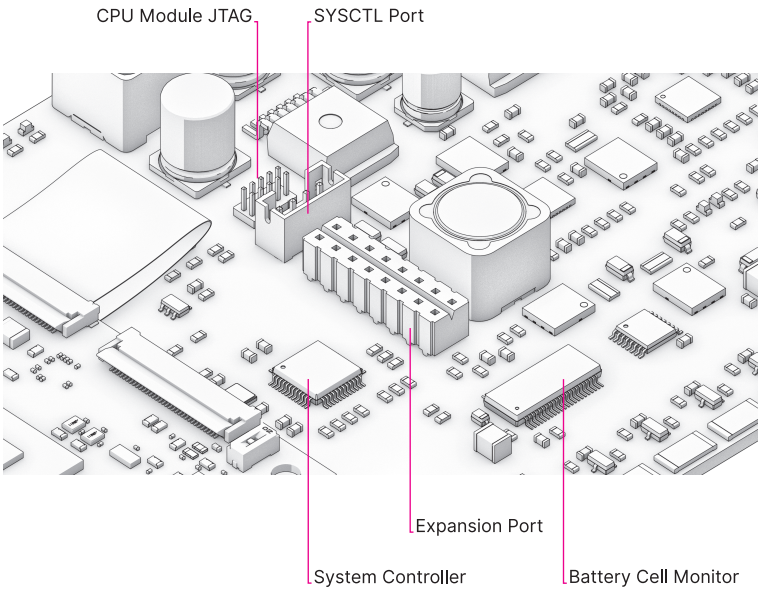
To update (flash) the firmware of the System Controller, you

need another computer and a Micro-USB cable.

You can find the source code of the firmware in the source folder reform2-lpc-fw.

1. Set DIP switch LPCPROG to “ON”.
2. Press button LPCRESET.
3. Connect Micro-USB cable.
4. System Controller’s memory appears as virtual flash drive on secondary computer (check `lsblk`).
5. Edit `flash.sh` and change the path to virtual flash drive (i.e. `/dev/sdx`). **Make sure the path is correct, or you could destroy data on your hard disk!**
6. Execute `flash.sh` as `root`.
7. Unplug Micro-USB cable.
8. Set DIP switch LPCPROG to “OFF”.
9. Press button LPCRESET.

9.2.3 Expansion Port



The Expansion Port U18, labeled “Hack the Planet” is meant for advanced users that want to connect sensors or other peripherals to MNT Reform’s system controller. Please note that changing the system controller’s program can disrupt the battery charging control loop, potentially causing over- or undercharged cells, resulting in physical damage and/or injury. **Experiment with the system controller only if you know exactly what you’re doing and at your own risk.**

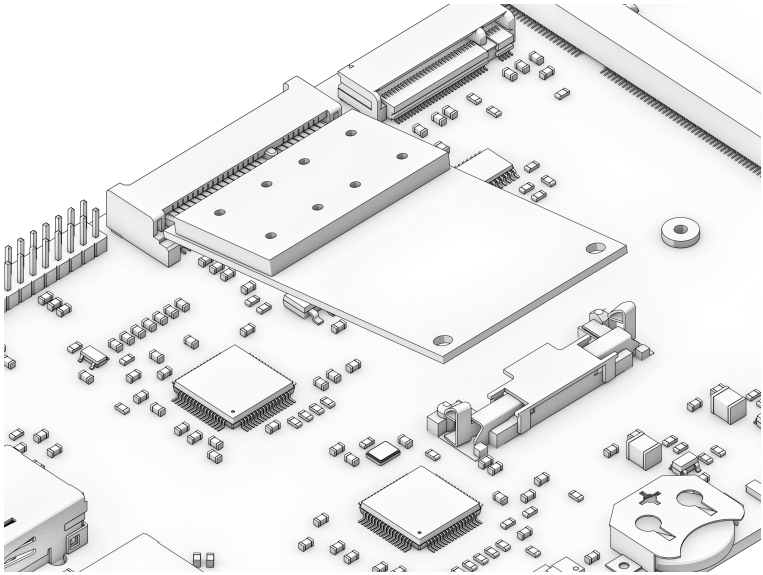
The Expansion Port features an SPI interface, two analog-digital converters, a UART, JTAG and 3.3V Power. All non-power pins can alternatively be used as GPIOs.

The following LPC11U24 pins are available at the port:

Pin	Function	Pin	Function
16	GND	15	3.3V
14	MOSI1a	13	USBCON#
12	RXDa	11	TXDa
10	AD7	9	SCLKa
8	SWDIO	7	AD5
6	TDO	5	TRST#
4	TDI	3	TMS
2	MISO1a	1	SCK0b

Refer to the motherboard schematic's *Power* section and the NXP LPC11U24 reference manual for further details.

9.2.4 mPCIe Socket



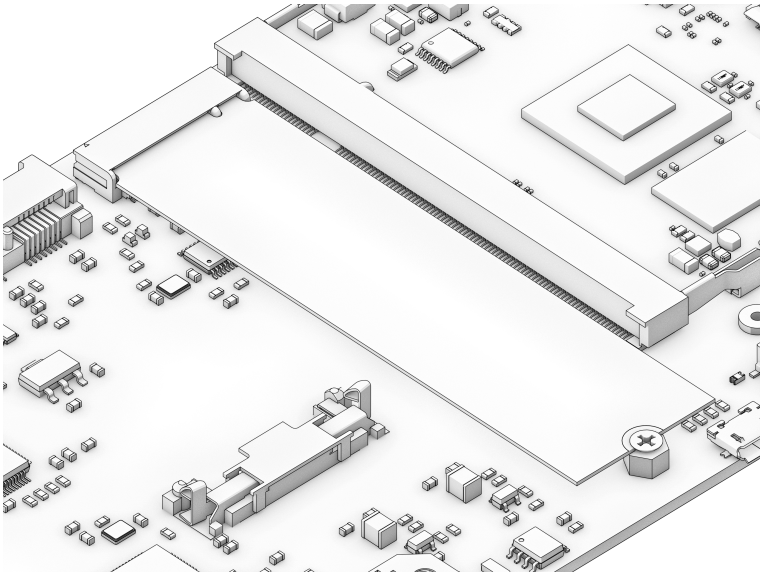
The default i.MX8M module features two PCIe controllers. The first one is connected to the mPCIe socket U11. The standard use for the mPCIe port is a WiFi card. To install a card, plug it into the socket at an angle and then press down the

opposing side into the latch. To remove the card, just pull on the two protruding metal springs of the latch and the card will pop out.

The mPCIe slot's power supply can be turned off completely by the System Controller's PCIE1_PWR_EN signal. This way, a kill switch can be implemented that is accessible from the OLED menu.

The reference clock of the mPCIe slot has to be provided by the CPU module.

9.2.5 M.2 Socket (Key M)

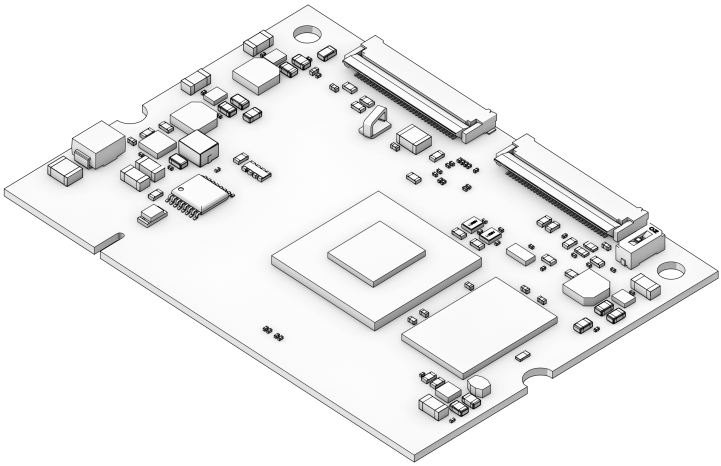


The second PCIe controller of the i.MX8M module is connected to the M.2 socket (J10). The standard use for the port is to install an M.2 NVMe solid state drive. Plug the NVMe module into the socket and fix it with an M2 screw to one of the three mounting holes that corresponds to the module's size.

Only one PCIe lane and the reset signal are connected to the

port. The reference clock for the port is generated by U23.

9.3 CPU Module



The CPU module is plugged into motherboard connector U1. It contains the main SoC (System-on-Chip) and memory as well as the ethernet PHY. MNT Reform release 1 ships with the Boundary Devices Nitrogen8M_SOM CPU module, which features an NXP i.MX8MQ SoC with 4x Cortex-A53 cores clocked at 1.5GHz, Vivante GC7000L GPU, 4GB LPDDR4 memory and 16GB eMMC flash storage. The schematics of this module are freely available on Boundary Devices' Website after creating an account.

At the time of writing, the following alternative CPU modules are in development:

- LS1028A Module with NXP LS1028A SoC (2x Cortex-A72, GC7000L GPU) and 8GB or 16GB LPDDR4 (Co-developed with RBZ, open source hardware)

- FPGA Module with Xilinx Kintex-7 and 2GB DDR3 memory, open source hardware

If you want to develop your own CPU module, visit `https://source.mnt.re/reform/reform-som-template` for a KiCAD template and more technical information.

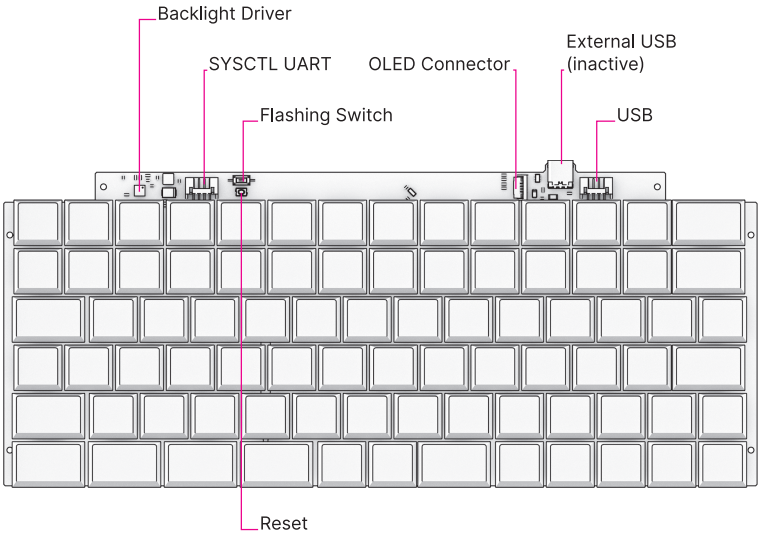
9.3.1 Display Connector

The default display in MNT Reform conforms to the eDP (embedded DisplayPort) standard. The Nitrogen8M_SOM outputs a MIPI-DSI signal on its flex connector that is fed into the J24 connector on the motherboard using the 30 pin, 0.5mm pitch flex cable. The SN65DSI86 chip on the motherboard converts the MIPI-DSI signal to eDP. If you use an alternative module that outputs eDP directly, the J24 connection is skipped. Refer to the manual of your module instead.

9.4 Heatsink

The heatsink is a piece of milled aluminum that connects to the silicon die of the main SoC on the CPU module, with a dab of thermal paste applied on the die. The heatsink is fixed to the motherboard by four M2×12 screws. The screws are supported by four plastic cylindrical spacers.

9.5 Keyboard



The Keyboard is mounted to the top of the Main Box with six M2×4 pan head screws. It is powered by an ATmega32U4 8-bit microcontroller. The controller scans the row/column matrix of keyswitches and reports keypresses via USB HID (human interface device) to the motherboard. Each switch has a diode to prevent ghosting, so you can press multiple keys at once. The microcontroller runs a firmware based on LUFA, which is an open source library for implementing USB input devices.

The second role of the keyboard is to serve as a user interface to the LPC system controller on the mainboard, even when the main SoC is turned off. To make this possible, the Keyboard connects via a separate UART cable to the motherboards SYSCTL header (J23).

9.5.1 Keyboard Firmware

You can find the MNT Reform keyboard firmware in the source folder reform2-keyboard-fw.

To modify the scancodes of the keyboard matrix, edit the file Keyboard.c and rebuild the firmware by typing the following command in a terminal:

```
make
```

To be able to flash the firmware to the keyboard, the ATmega has to be in a special mode where it identifies as an "Atmel DFU bootloader" USB device.

Remove the keyboard's frame and toggle the programming DIP switch SW84 on the keyboard to "ON". Then press the reset button SW83. Before doing this, you need a means to start the flashing command without MNT Reform's internal keyboard. You can use an external USB keyboard, or use the trackball/trackpad to copy and paste the flash command and a new line.

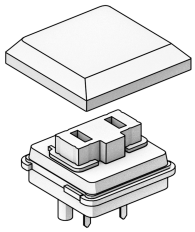
The keyboard will reappear as a Atmel DFU bootloader USB device. You can then upload your new firmware by executing:

```
./flash.sh
```

9.5.2 Backlight

Most keys have a white light emitting diode (LED) to illuminate the transparent part of the keycaps, making the laser engraved letters visible in darkness. You can control the backlight's brightness via Circle key combinations or the OLED menu.

9.5.3 Replacing a Keycap



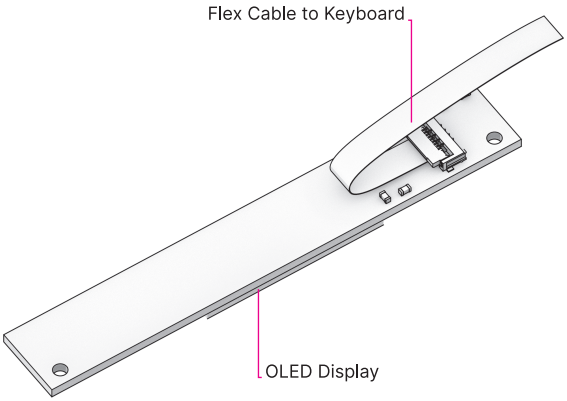
MNT Reform comes with custom *MBK* keycaps by FKcaps, but you can use any keycaps compatible with Kailh Choc keyswitches. You can easily pull out individual keycaps with your fingernails—or better, using a keycap puller—and swap them around. The only two keycap sizes on the keyboard are 1U and 1.5U.

9.5.4 Replacing a Keyswitch

Should a keyswitch ever break, you can replace it with Kailh Choc Brown (CPG135001D02).

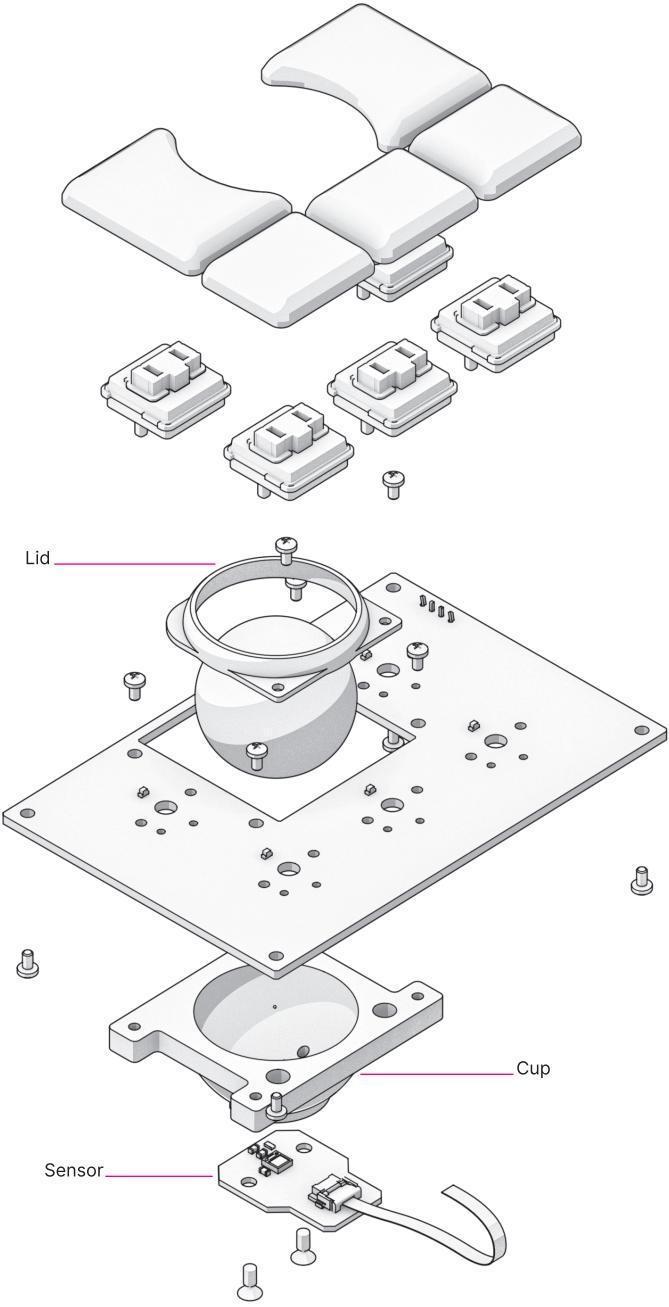
Use a soldering iron and solder wick to remove the solder of one pin. Try to pull out the corresponding side of the switch from the top while continuing to heat the pin. Repeat the same for the other pin and go back and forth until you can remove the switch.

9.6 OLED Module



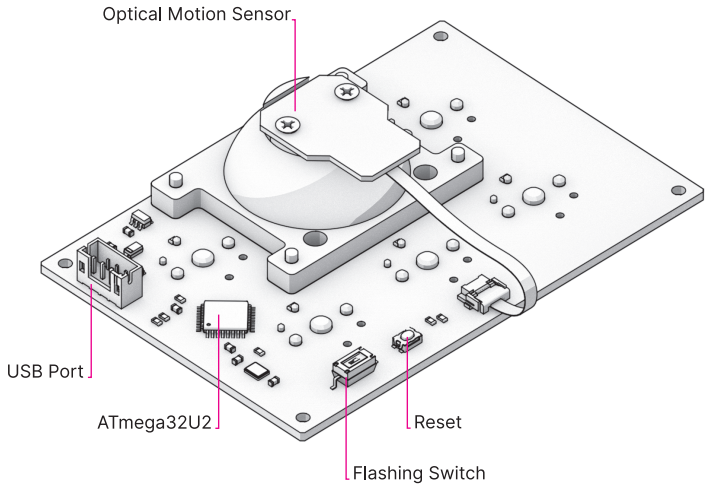
The OLED display sits on the OLED Module which is connected to the keyboard through a 4-pin, 1mm pitch flex cable. The communication protocol is I²C. The module is mounted in the Main Box on top of the keyboard with two M2×4 pan head screws.

9.7 Trackball



The trackball uses the same microcontroller and LUFA library as the keyboard, but instead of scanning a matrix of switches, it gets X and Y movement coordinates from the PAT9125EL optical sensor that is connected via I²C. The electronic connection between trackball sensor and controller is made with a 6-pin 0.5mm pitch flex cable.

The trackball has five buttons. These make use of the same keyswitches as the keyboard: Kailh Choc Brown (CPG135001D02). The button caps are 3D printed using SLA technology (Formlabs Form 2). If you want to substitute your own replacements, you can find the STL files for the caps in the MNT Reform source repository. The cup and lid of the trackball are 3D printed using the same method.



9.7.1 Trackball Cleaning

From time to time, you should clean dust and debris from the trackball. To do this, carefully lift off the left and right buttons. Then, unscrew the two screws holding the trackball's lid and remove the ball. Clean the inside of the cup with a soft cloth.

Don't use detergents as these can dissolve the cup's material.

9.7.2 Trackball Firmware

You can find the trackball firmware in the source folder reform2-trackball-fw.

The trackball firmware is based on the LUFA USB device library and implements a USB HID Mouse. To modify the behavior of the trackball, edit the file Mouse.c and rebuild the firmware by typing the following command in a terminal:

```
make
```

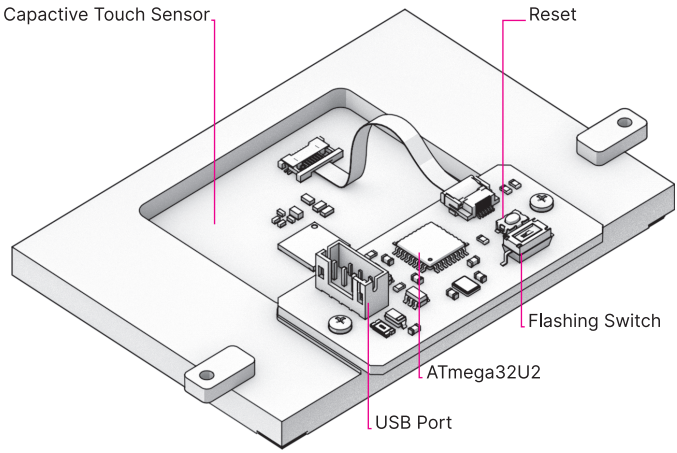
Same as the keyboard, the trackball's MCU has to be in bootloader USB mode for flashing. Toggle the programming DIP switch SW7 on the trackball controller to "ON" and press the reset button SW6.

The trackball will reappear as an "Atmel DFU bootloader" USB device. You can then upload your new firmware by executing:

```
./flash.sh
```

9.8 Trackpad

The trackpad uses the same microcontroller as the keyboard and trackball. To sense the touch and motion of fingers, it integrates an Azoteq TPS65-201 capacitive sensor which reports coordinates to the microcontroller via the SPI protocol.



9.8.1 Trackpad Firmware

You can find the trackpad firmware in the source folder reform2-trackpad-fw.

Same as the trackball and keyboard, the trackpad firmware is based on the LUFA USB device library and implements a USB HID Mouse. To modify the behavior of the trackpad, edit the file Mouse.c and rebuild the firmware by typing the following command in a terminal:

```
make
```

For flashing, the MCU has to be in bootloader USB mode. Toggle the programming DIP switch SW7 to “ON” and press the reset button SW6. The trackpad will reappear as an “Atmel DFU bootloader USB” device. You can then upload your new firmware by executing:

```
./flash.sh
```

9.9 Exchanging Trackball and Trackpad

You can easily swap the Trackball for the Trackpad module and vice versa. To do this, first disconnect the wall power and flip MNT Reform on its back. Open the Bottom Plate and remove all battery cells. Unplug the side of the internal USB cable that is connected to the installed module. Then, unscrew the module's case mounting screws (four M2×4 pan head screws for the Trackball, two M2×4 pan head screws for the Trackpad) and pull out the module. Reverse the process to install the new input device. The Trackball is inserted so that its four mounting holes line up with four matching holes in the Main Box. The Trackpad slides into a slot in the Main Box with one end first (the end without mounting tabs) and is then mounted to the Main Box with two screws that go through the tabs on the other end. After mounting the desired module, reconnect the internal USB cable to it.

9.10 Battery Packs

MNT Reform has two identical battery packs, referred to as the Left and Right packs. Each pack has four 18650 cells with LiFePO4 chemistry (3.2V) and is mounted to the Main Box with four M2×4 pan head screws. You may be tempted to try cells of other chemistries like Li-Ion or NiMH, **but never do this, as these are incompatible.**

Only use LiFePO4 cells with MNT Reform!

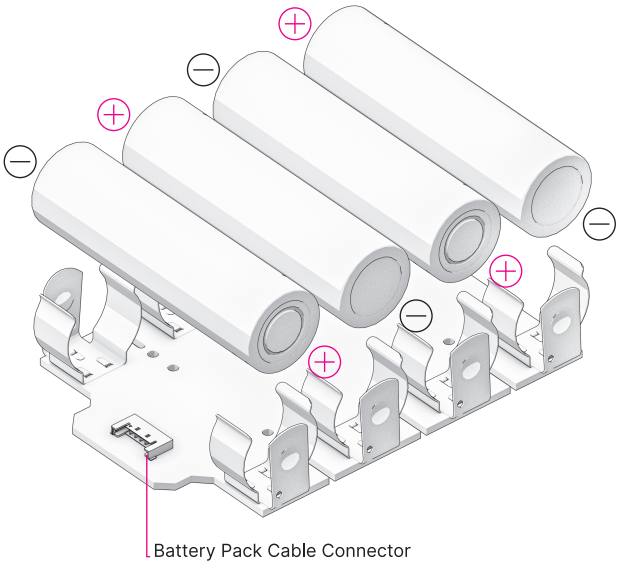
When inserting battery cells, **make sure that the positive and negative poles are facing in the correct direction.** The poles are marked on the silkscreen of the battery pack PCBs.

All 8 cells are connected in series. When fully charged at 3.6V, the total voltage of the cells can add up to 28.8V. **Make sure not to bridge/short any battery clips to the case or neighboring clips or pins, as this will immediately cause sparks and burnt traces.**

When working inside MNT Reform, remove all battery cells.

This way you can easily prevent damage from accidental discharge.

LiFePO4 cells are safely discharged to 2.5V. Please make sure not to discharge the cells further. If you plan to leave your MNT Reform turned off/uncharged for more than a few days, disconnect the battery packs or take out the cells to avoid deep discharge.



9.10.1 Compatible Battery Cells

The following table lists compatible LiFePO4 cells, but any LiFePO4 chemistry cell of 18650 size should work. It is not recommended to mix cells of different capacities, as the lowest capacity cell will dictate the lowest safe point of discharge.

Brand	Model	Capacity
JGNE	MH48108	1800mAh
IFR	18650 LiFePO4	1400mAh
LithiumWerks	APR18650M1-B	1100mAh
Sony Konion	US18650FTC1	1100mAh

9.11 Compatible Displays

MNT Reform was designed to be compatible with a number of 13.3 inch (diagonal) 1920×1080 pixel eDP displays. We tested the following display models successfully:

Brand	Model
Innolux	N125HCE-GN1 (Center Connector)
Innolux	N125HCE-GN1 (Side Connector)
Innolux	N125HCE-GPA (glossy or matte)
BOE	NV125FH1-N82
AU Optronics	B125HAN02.2

Chapter 10

Advanced Topics

10.1 Troubleshooting

Here are some things you can try if MNT Reform should stop booting (in order of increasing difficulty):

- Press *Circle*, then *0* (zero), then *1* (one) to power cycle the system and wait at least 30 seconds.
- Remove the Bottom Plate and press the LPC_RST button on the motherboard to reset the System Controller.
- Download the MNT Reform System Image from the MNT Research website and flash it to a fresh SD Card. Then try to boot from this SD Card.
- Try to boot from the backup system on eMMC (see *System Boot* below).
- Strip MNT Reform down to a minimal system (remove all peripherals) and check for output on the serial/UART console.
- Measure individual power rails (only for advanced users with electronics knowledge).

As always, before working with MNT Reform internals, first disconnect the internal battery and external power and peripherals.

10.1.1 Serial Console

The motherboard connector labeled SER1 is a serial port (UART) to which U-Boot and the Linux kernel output diagnostic information on startup. The baud rate is 115200, 8N1.

Wire up a generic USB-to-UART adapter to the following pins of connector J18:

Pin	Function
1	UART1_TXD, connect to RX of your adapter
2	UART1_RXD, connect to TX of your adapter
3	GND, connect to GND of your adapter

Then, use a terminal program such as `screen` on your host computer:

```
screen /dev/ttyUSB0 115200
```

If you then switch on Reform (powered by the wall adapter) with the provided SD card inserted, you should see the U-Boot console in `screen`.

10.1.2 Power Rails

Reform will accept 9-32V of DC power on barrel jack J1. The nominal input voltage is 24V. If you can't measure the input voltage on R49, check if fuse F1 is blown.

Either wall or battery power will be regulated to ~29V by the buck-boost regulator/charger LTC4020 and output to the main system regulators. U14 is the always-on 3V3 regulator that powers critical chips like the System Controller (LPC11U24, U18). You can confirm LPC_VCC power with 3.3V on J22 pin 15.

Two white indicator LEDs on the motherboard, D11 and D12, signal that 3.3V and 5V rails are turned on, respectively. The i.MX8M processor module has a green LED that signals 5V power arriving at the module. Because of the level shifters U28 and U8, booting from the SD card requires both 3.3V and 1.8V rails to work. You can measure 1.8V on C130, for example. Booting from eMMC requires only 5V power to go into the CPU module.

The USB hub U9 and the MIPI to eDP converter U10 also need 1.2V power to work (measure on C37). The display itself requires the 3V3_PWR_AUX (3.3V) and USB_PWR (5V) rails to be switched on by the System Controller.

10.1.3 SYSCTL

The System Controller has to have working firmware to turn on the main power rails. If it is not responding to OLED menu / Circle Key commands, you can use a UART adapter on SYSCTL header J23 to talk to the System Controller directly (57600 baud 8N1). To do this, you'll need to solder/crimp an adapter cable with a JST-PH plug.

10.2 System Boot

i.MX8MQ will try to load boot code from either the eMMC flash on the module or from the SD card (default), depending on the setting of the DIP switch on the Nitrogen8M_SOM module. MNT Reform comes with the U-Boot bootloader on both the eMMC and on the SD Card.

U-Boot is a mini operating system and shell that allows you to inspect parts of the system (like PCIe, USB devices or Ethernet) and set up parameters to be passed to the real operating system kernel such as Linux, and start it.

U-Boot itself has to be compiled with the board support files for Reform. This is done by the `mkuboot.sh` script that is part

of the `reform-system-image` repository. The resulting file, processed to be in the correct format loadable by the i.MX8MQ processor is `flash.bin`. This file has to be written to the boot medium at an offset of 33kB (33792 bytes).

The build process combines the following files into `flash.bin`:

- Synopsys DDR4 calibration firmware `lpddr4_pmu_train_*.bin` (no source available)
- Cadence HDMI controller firmware `signed_hdmi_imx8m.bin` (no source available, optional)
- ARM trusted firmware "TF-A" `bl31-iMX8MQ.bin` (open source)
- The u-boot binary (open source)

U-Boot needs 2 files to boot Linux:

- The Linux kernel itself, named `Image`.
- The device tree blob (DTB), which depends on the CPU module. For i.MX8MQ, this is called `imx8mq-mnt-reform2.dtb`. The device tree is a data structure that lists the addresses of and parameters for all the devices in the system that Linux needs to initialize drivers for. The source for this file is `imx8mq-mnt-reform2.dts`, and it is compiled to the DTB as part of the Linux kernel tree (where it resides in (`arch/arm64/boot`).

Theoretically, you can boot other operating systems besides Linux, such as FreeBSD, NetBSD, OpenBSD or anything else that supports the i.MX8MQ SoC. This handbook covers only the Linux operating system, but you can—if drivers exist—boot any of these operating systems from U-Boot.

The default boot script will load the DTB and Kernel Image from the SD card using the following command:

```
ext4load mmc 1 ${loadaddr} /Image
ext4load mmc 1 ${fdt_addr} /imx8mq-mnt-reform2.dtb
booti ${loadaddr} - ${fdt_addr}
```

This means that the Kernel and DTB files reside in the root directory of the boot medium, which has to be the first partition, Ext4 formatted.

You can interrupt this script within the first second of boot by sending a character (key press) via the SER1 UART and type `help` to get a list of supported commands. You can inspect all environment variables with the `printenv` command.

The Linux kernel parameters are passed via the `bootargs` U-Boot environment variable:

```
noinitrd root=/dev/mmcblk1p1 rootwait rw
  console=ttymxc0,115200 console=tty1 cma=512M
  pci=nomsi
```

This tells the kernel to mount the root filesystem from the `mmcblk1p1` device, which is the first partition on the SD card. To boot from the second partition, for example, you would change this to `mmcblk1p2`. `mmcblk0...` is the eMMC flash. `ttymxc0` is the serial UART SER1. `cma=512M` sets up a memory area for contiguous allocation for the GPU. `pci=nomsi` turns off message-signaled interrupts (MSI) for the PCIe controller, which helps with some WiFi cards.

10.3 Operating System on NVMe

If you want to mount your root filesystem from an NVMe disk, you only need to partition it and copy the Linux filesystem to it. One way to do this is to copy the existing Linux system from the SD card to an NVMe disk.

First mount the target disk at `/mnt` (as root):

```
mount /dev/nvme0n1p1 /mnt/
```

Then, copy the operating system and all your files (as root):

```
rsync -axHAWXS --numeric-ids --info=progress2 / /mnt/
umount /mnt
```

10.3.1 Encrypted NVMe

If you want to protect the data on your NVMe disk in case you lose your MNT Reform, you can encrypt it with LUKS. You can do that manually or use the `gnome-disks` tool.

Copy your filesystem to the encrypted disk like above, but substituting `nvme0n1p1` for the corresponding LUKS device mapper name.

To let Linux load your root filesystem from your encrypted disk, you need a way to enter the decryption passphrase at boot time. The provided script `/sbin/reform-init` (on the SD card or eMMC) can handle this for you. Edit it to your liking and then change the kernel parameters in U-Boot:

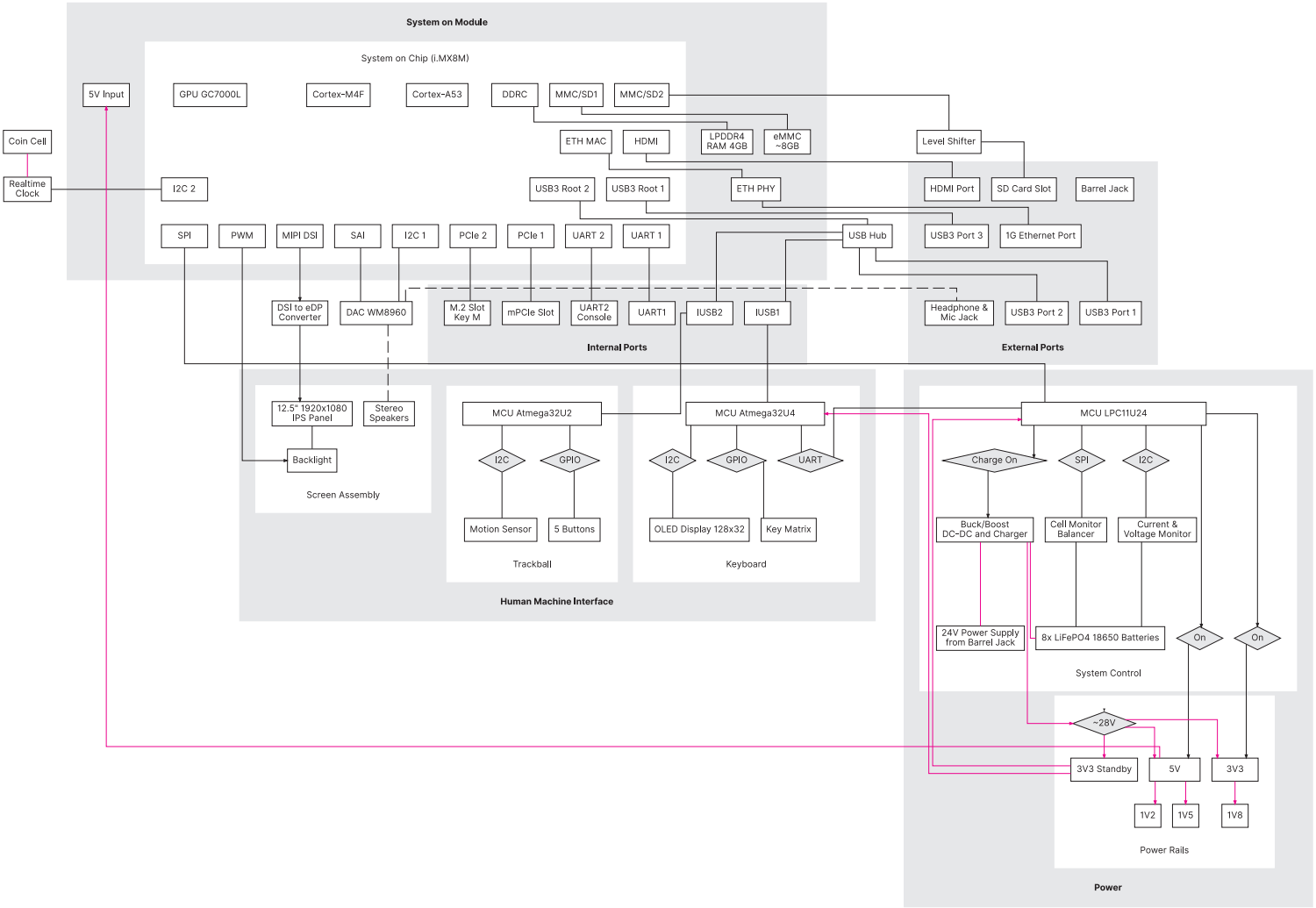
```
setenv bootargs noinitrd root=/dev/mmcblk1p1 rootwait
  rw console=ttymxc0,115200 console=tty1 cma=512M
  pci=nomsi init=/sbin/reform-init
saveenv
boot
```

To make this process more convenient for you, you can use the provided interactive script `reform-migrate` to migrate your MNT Reform operating system and files to a different disk:

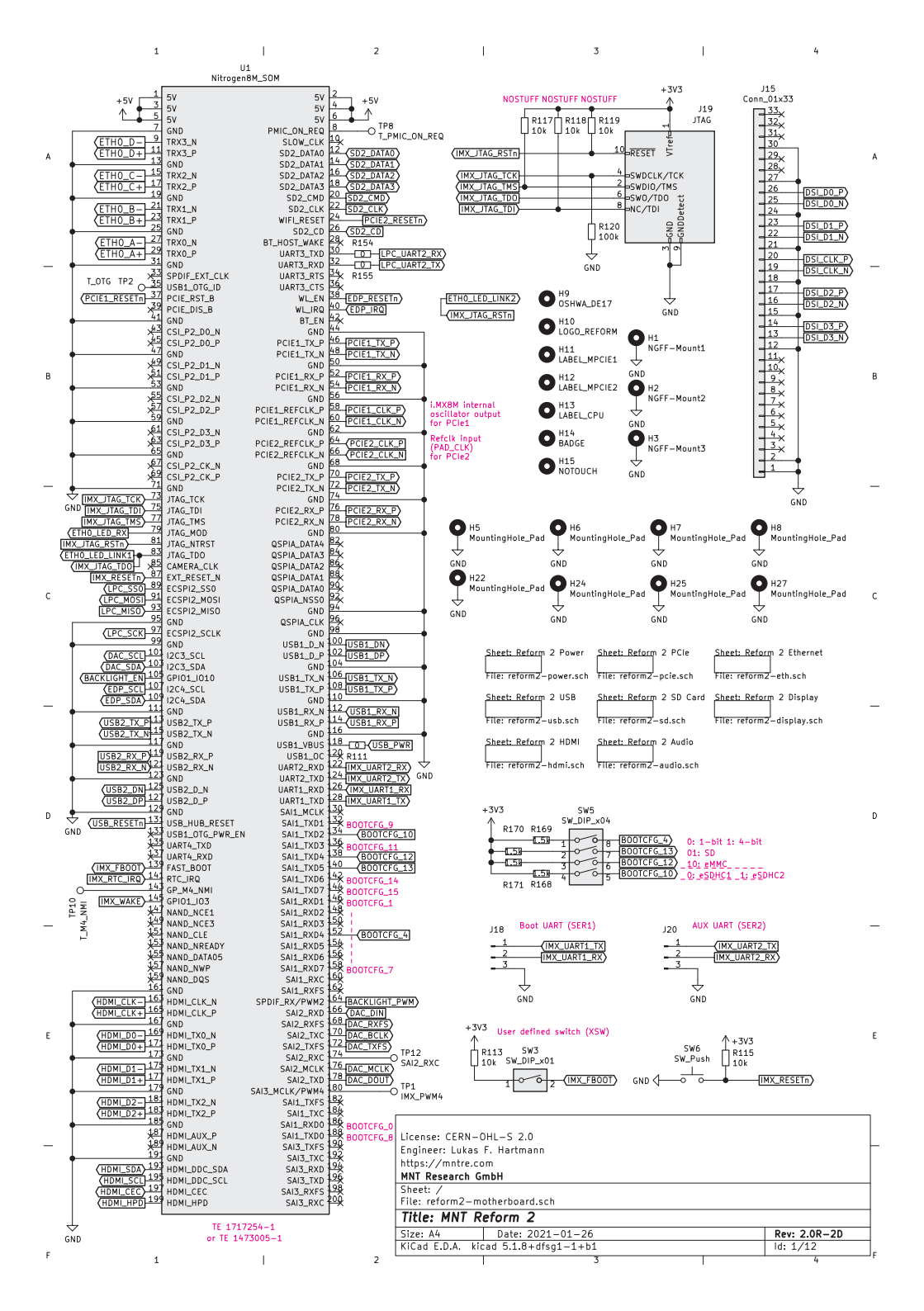
```
sudo /sbin/reform-migrate
```

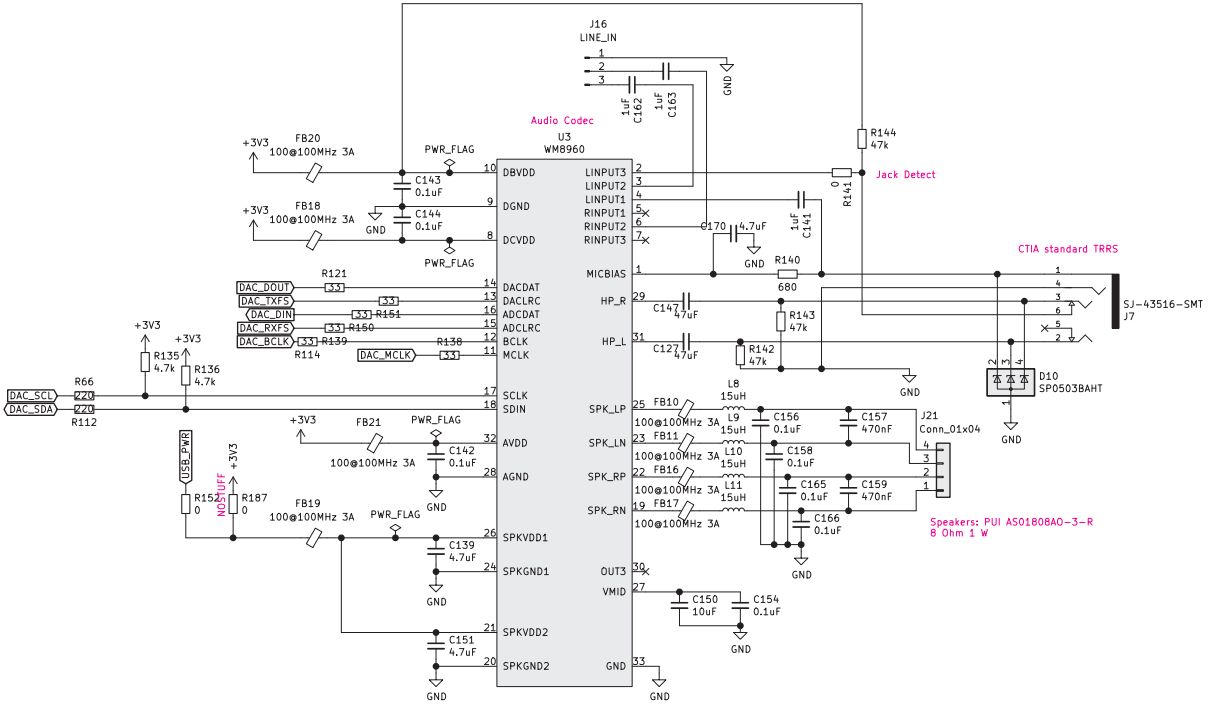
Chapter 11

Schematics


System on Module
System on Chip (i.MX8M)
5V Input
GPU GC7000L
Cortex-M4F
Cortex-A53
DDRC
MMC/SD1
MMC/SD2
Coin Cell
Realtime Clock
I2C 2
ETH MAC
HDMI
LPDDR4 RAM 4GB
eMMC ~8GB
Level Shifter
USB3 Root 2
USB3 Root 1
ETH PHY
HDMI Port
SD Card Slot
Barrel Jack
SPI
PWM
MIPI DSI
SAI
I2C 1
PCIe 2
PCIe 1
UART 2
UART 1
USB Hub
USB3 Port 3
1G Ethernet Port
DSI to eDP Converter
DAC WM8960
M.2 Slot Key M
mPCIe Slot
UART2 Console
UART1
IUSB2
IUSB1
Headphone & Mic Jack
USB3 Port 2
USB3 Port 1
Internal Ports
External Ports
12.5" 1920x1080 IPS Panel
Stereo Speakers
Backlight
Screen Assembly
MCU Atmega32U2
I2C
GPIO
Motion Sensor
5 Buttons
Trackball
MCU Atmega32U4
I2C
GPIO
UART
OLED Display 128x32
Key Matrix
Keyboard
Human Machine Interface
MCU LPC11U24
Charge On
SPI
I2C
Buck/Boost DC-DC and Charger
Cell Monitor Balancer
Current & Voltage Monitor
24V Power Supply from Barrel Jack
8x LiFePO4 18650 Batteries
On
On
System Control
~28V
3V3 Standby
5V
3V3
1V2
1V5
1V8
Power Rails
Power

11.1 Motherboard Schematics


U1
Nitrogen8M_SOM
TE 1717254-1
or TE 1473005-1
J19
JTAG
J15
Conn_01x33
NOSTUFF NOSTUFF NOSTUFF
R117 10k
R118 10k
R119 10k
R120 100k
IMX_JTAG_RSTn
IMX_JTAG_TCK
IMX_JTAG_TMS
IMX_JTAG_TDO
IMX_JTAG_TDI
RESET
SWDCLK/TCK
SWDIO/TMS
SWO/TDO
NC/TDI
VTref
GND
GNDDetect
+3V3
+5V
GND
T_OTG TP2
TP8
T_PMIC_ON_REQ
R154
R155
R111
ETH0_LED_LINK2
i.MX8M internal oscillator output for PCIe1
Refclk input (PAD_CLK) for PCIe2
H9 OSHWA_DE17
H10 LOGO_REFORM
H11 LABEL_MPCIE1
H12 LABEL_MPCIE2
H13 LABEL_CPU
H14 BADGE
H15 NOTOUCH
H1 NGFF-Mount1
H2 NGFF-Mount2
H3 NGFF-Mount3
H5 MountingHole_Pad
H6 MountingHole_Pad
H7 MountingHole_Pad
H8 MountingHole_Pad
H22 MountingHole_Pad
H24 MountingHole_Pad
H25 MountingHole_Pad
H27 MountingHole_Pad
Sheet: Reform 2 Power
File: reform2-power.sch
Sheet: Reform 2 PCIe
File: reform2-pcie.sch
Sheet: Reform 2 Ethernet
File: reform2-eth.sch
Sheet: Reform 2 USB
File: reform2-usb.sch
Sheet: Reform 2 SD Card
File: reform2-sd.sch
Sheet: Reform 2 Display
File: reform2-display.sch
Sheet: Reform 2 HDMI
File: reform2-hdmi.sch
Sheet: Reform 2 Audio
File: reform2-audio.sch
SW5
SW_DIP_x04
R170 4.5k
R169 4.5k
R171 4.5k
R168 4.5k
BOOTCFG_4
BOOTCFG_13
BOOTCFG_12
BOOTCFG_10
0: 1-bit 1: 4-bit
0: SD
10: eMMC _ _ _ _
0: eSDHC1 _1: eSDHC2
J18
Boot UART (SER1)
J20
AUX UART (SER2)
User defined switch (XSW)
R113 10k
SW3
SW_DIP_x01
SW6
SW_Push
R115 10k
TP12
SAI2_RXC
TP1
IMX_PWM4
TP10
T_M4_NMI
License: CERN-OHL-S 2.0
Engineer: Lukas F. Hartmann
https://mntre.com
MNT Research GmbH
Sheet: /
File: reform2-motherboard.sch
Title: MNT Reform 2
Size: A4
Date: 2021-01-26
Rev: 2.0R-2D
KiCad E.D.A. kicad 5.1.8+dfsg1-1+b1
Id: 1/12



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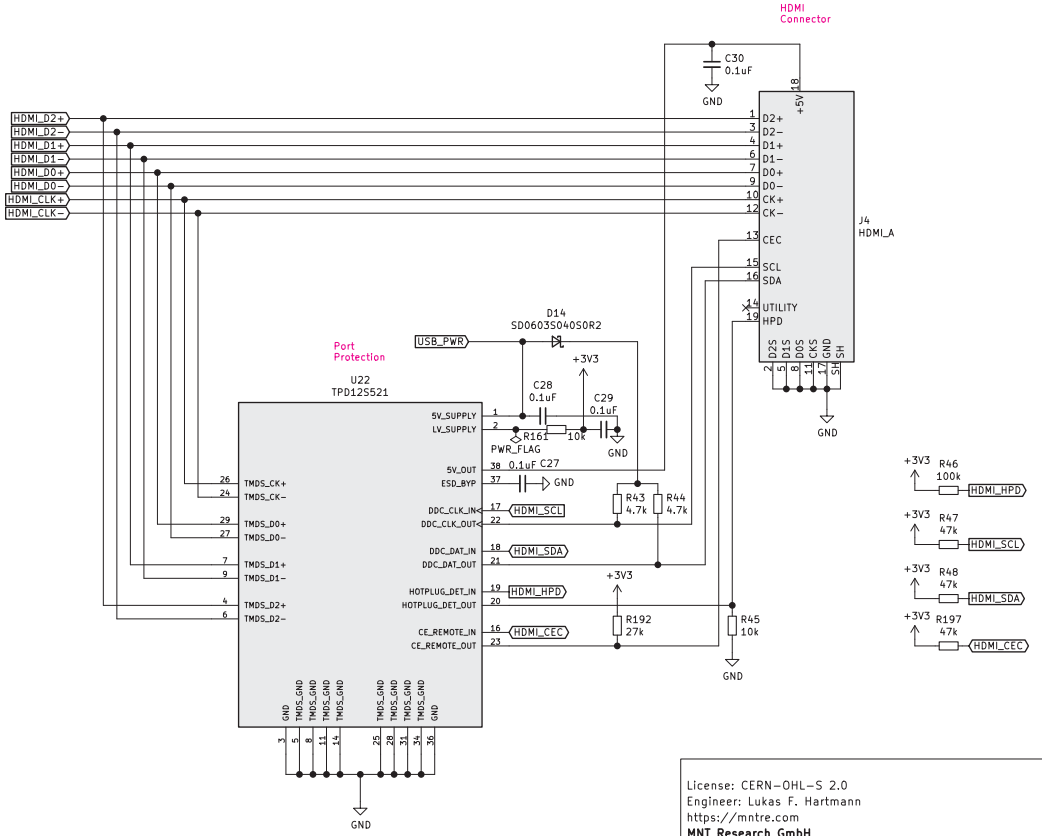
Sheet: /Reform 2 Audio/
File: reform2-audio.sch

Title: Reform 2 Audio

Size: A4	Date: 2021-01-26	**Rev: 2.0R-2D**
KiCad E.D.A. kicad 5.1.8+dfsg1-1+b1		Id: 2/12



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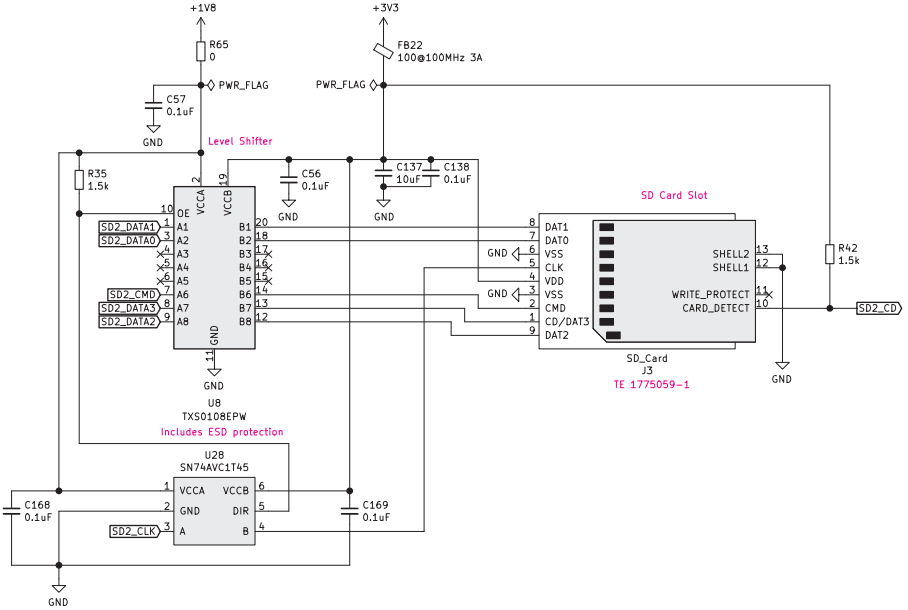
Sheet: /Reform 2 HDMI/
File: reform2−hdmi.sch

Title: MNT Reform 2 External Display

Size: A4	Date: 2021−01−26	**Rev: 2.0R−2D**
KiCad E.D.A. kicad 5.1.8+dfsg1−1+b1		Id: 3/12



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https://mntre.com
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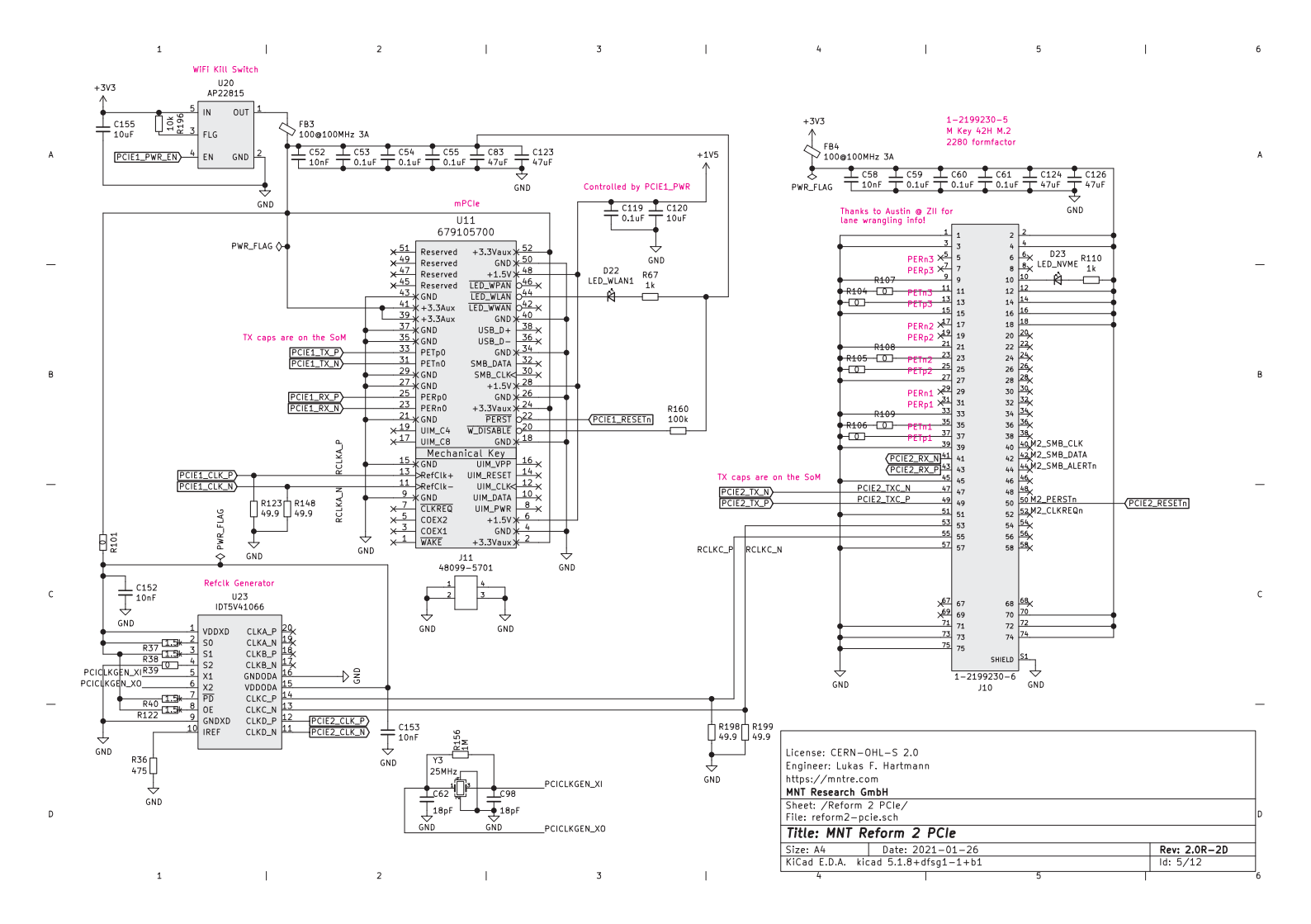
Sheet: /Reform 2 SD Card/
File: reform2-sd.sch

Title: MNT Reform 2 SD Card

Size: A4	Date: 2021-01-26	**Rev: 2.0R-2D**
KiCad E.D.A. kicad 5.1.8+dfsg1-1+b1		Id: 4/12


WiFi Kill Switch
U20
AP22815
IN
OUT
FLG
EN
GND
PCIE1_PWR_EN
C155
10uF
R196
10k
FB3
100@100MHz 3A
C52
10nF
C53
0.1uF
C54
0.1uF
C55
0.1uF
C83
47uF
C123
47uF
+3V3
+1V5
GND
Controlled by PCIE1_PWR
C119
0.1uF
C120
10uF
mPCIe
U11
679105700
PWR_FLAG
Reserved
+3.3Vaux
GND
+1.5V
LED_WPAN
LED_WLAN
LED_WWAN
USB_D+
USB_D-
SMB_DATA
SMB_CLK
PERST
W_DISABLE
UIM_C4
UIM_C8
UIM_VPP
UIM_RESET
UIM_CLK
UIM_DATA
UIM_PWR
CLKREQ
COEX2
COEX1
WAKE
Mechanical Key
D22
LED_WLAN1
R67
1k
TX caps are on the SoM
PCIE1_TX_P
PCIE1_TX_N
PCIE1_RX_P
PCIE1_RX_N
PCIE1_RESETn
R160
100k
PETp0
PETn0
PERp0
PERn0
RefClk+
RefClk-
PCIE1_CLK_P
PCIE1_CLK_N
RCLKA_P
RCLKA_N
R123
49.9
R148
49.9
R101
PWR_FLAG
C152
10nF
Refclk Generator
U23
IDT5V41066
VDDXD
S0
S1
S2
X1
X2
PD
OE
GNDXD
IREF
CLKA_P
CLKA_N
CLKB_P
CLKB_N
GNDDDA
VDDDDA
CLKC_P
CLKC_N
CLKD_P
CLKD_N
R37
1.5k
R38
0
R39
0
R40
1.5k
R122
1.5k
PCICLKGEN_XI
PCICLKGEN_XO
R36
475
C153
10nF
PCIE2_CLK_P
PCIE2_CLK_N
R156
1M
Y3
25MHz
C62
18pF
C98
18pF
J11
48099-5701
1-2199230-5
M Key 42H M.2
2280 formfactor
FB4
100@100MHz 3A
C58
10nF
C59
0.1uF
C60
0.1uF
C61
0.1uF
C124
47uF
C126
47uF
Thanks to Austin @ ZII for
lane wrangling info!
D23
LED_NVME
R110
1k
PERn3
PERp3
PETn3
PETp3
PERn2
PERp2
PETn2
PETp2
PERn1
PERp1
PETn1
PETp1
R107
R104
R108
R105
R109
R106
M2_SMB_CLK
M2_SMB_DATA
M2_SMB_ALERTn
M2_PERSTn
M2_CLKREQn
PCIE2_RESETn
PCIE2_TX_N
PCIE2_TX_P
PCIE2_TXC_N
PCIE2_TXC_P
PCIE2_RX_N
PCIE2_RX_P
RCLKC_P
RCLKC_N
SHIELD
1-2199230-6
J10
R198
49.9
R199
49.9
License: CERN-OHL-S 2.0
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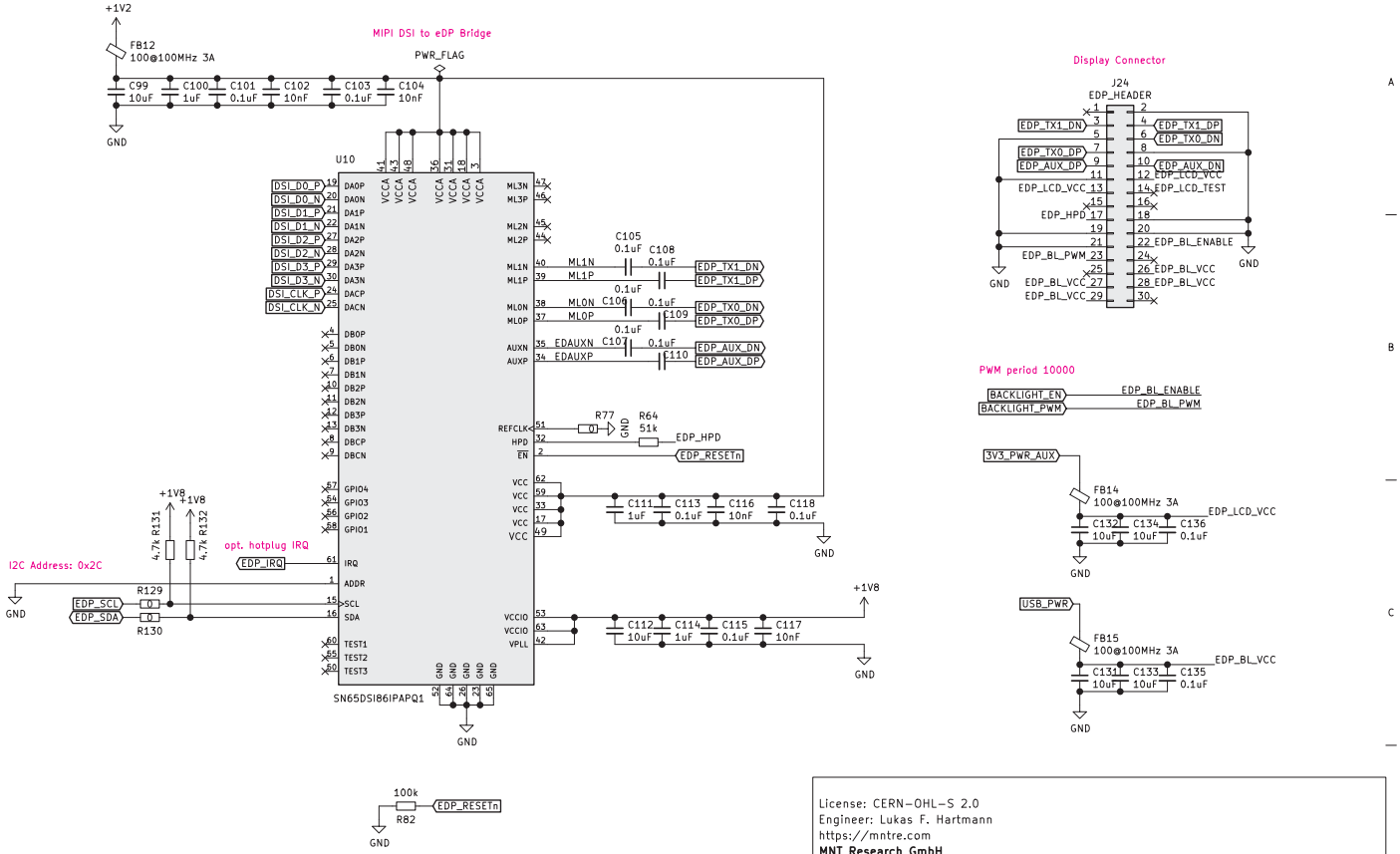
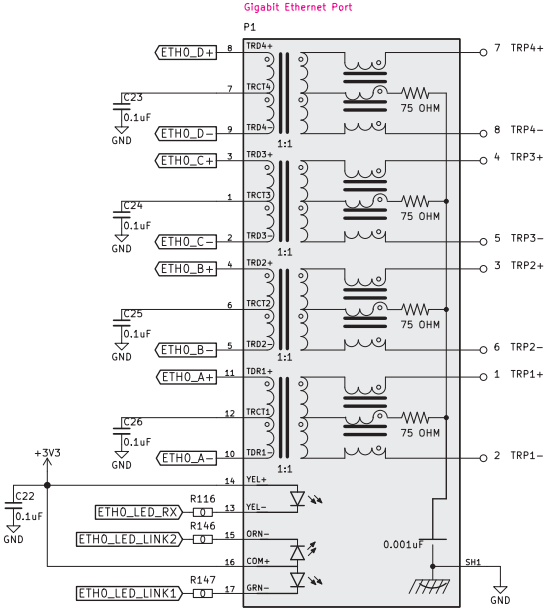
Sheet: /Reform 2 PCIe/
File: reform2-pcie.sch
Title: MNT Reform 2 PCIe
Size: A4
Date: 2021-01-26
Rev: 2.0R-2D
KiCad E.D.A. kicad 5.1.8+dfsg1-1+b1
Id: 5/12


MIPI DSI to eDP Bridge
Display Connector
PWM period 10000
SN65DSI86IPAPQ1
I2C Address: 0x2C
opt. hotplug IRQ
License: CERN-OHL-S 2.0
Engineer: Lukas F. Hartmann
https://mntre.com
MNT Research GmbH
Sheet: /Reform 2 Display/
File: reform2-display.sch
Title: MNT Reform 2 Internal Display
Size: A4
Date: 2021-01-26
Rev: 2.0R-2D
KiCad E.D.A. kicad 5.1.8+dfsg1-1+b1
Id: 6/12



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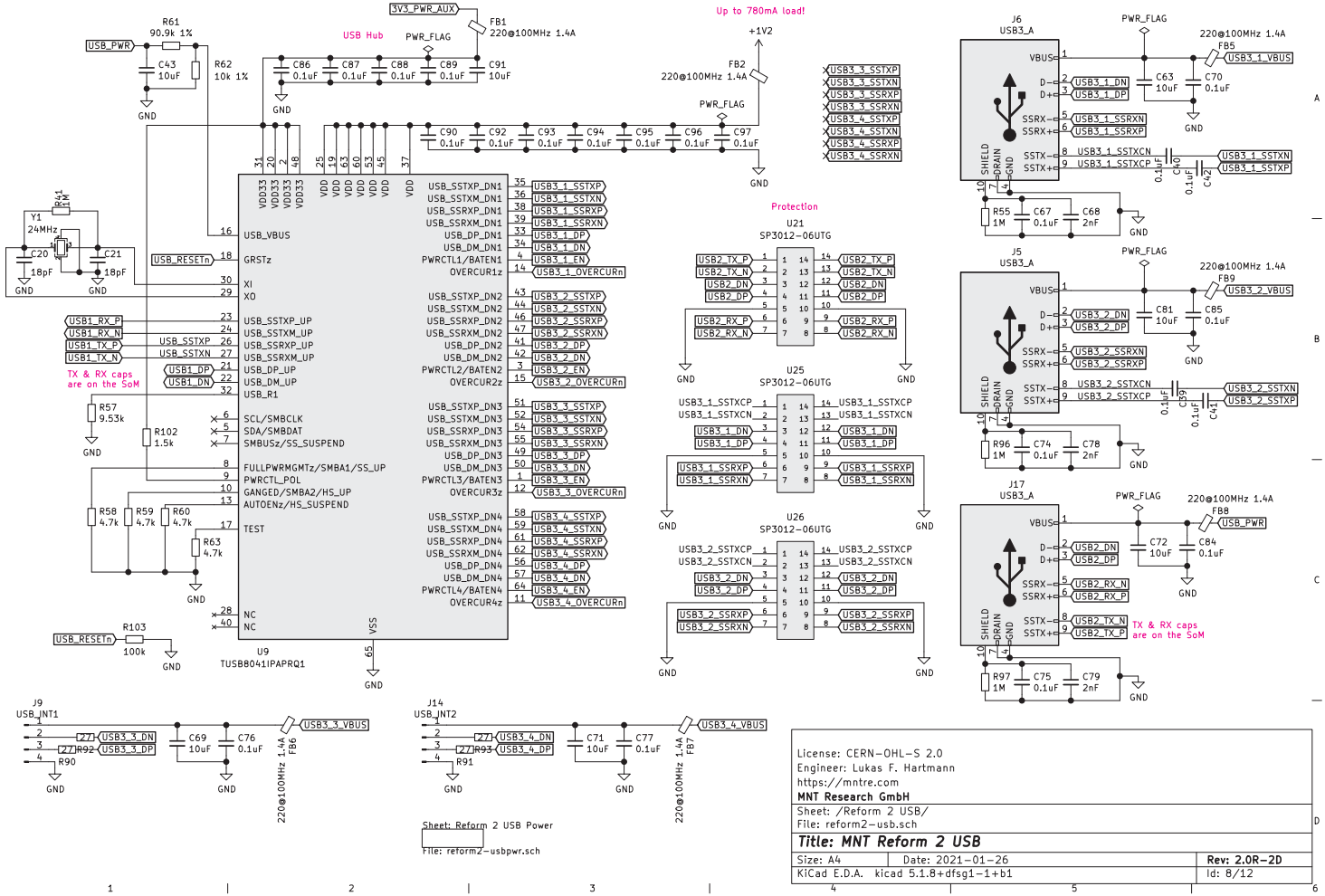
Sheet: /Reform 2 Ethernet/
File: reform2-eth.sch

Title: MNT Reform 2 Ethernet

Size: A4	Date: 2021-01-26	**Rev: 2.0R-2D**
KiCad E.D.A. kicad 5.1.8+dfsg1-1+b1		Id: 7/12



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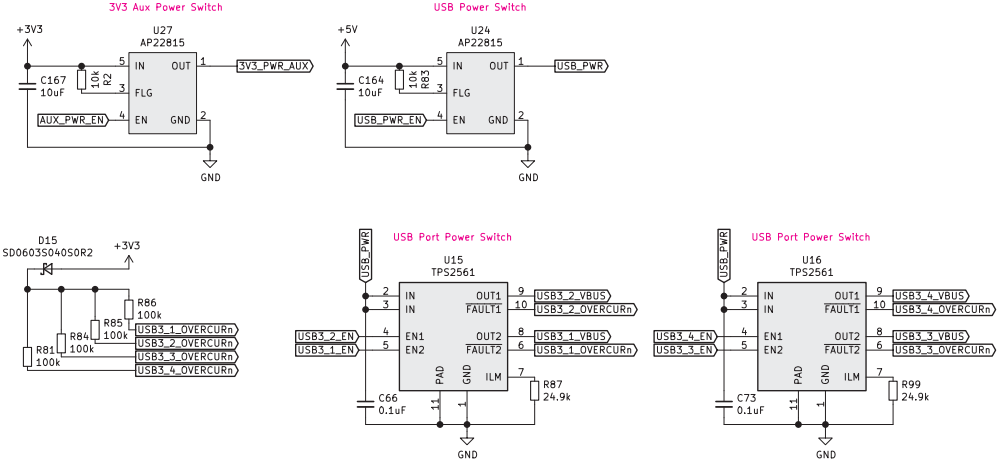
Sheet: /Reform 2 USB/
File: reform2-usb.sch

Title: MNT Reform 2 USB

Size: A4	Date: 2021-01-26	**Rev: 2.0R-2D**
KiCad E.D.A. kicad 5.1.8+dfsg1-1+b1		Id: 8/12



Engineer: Lukas F. Hartmann
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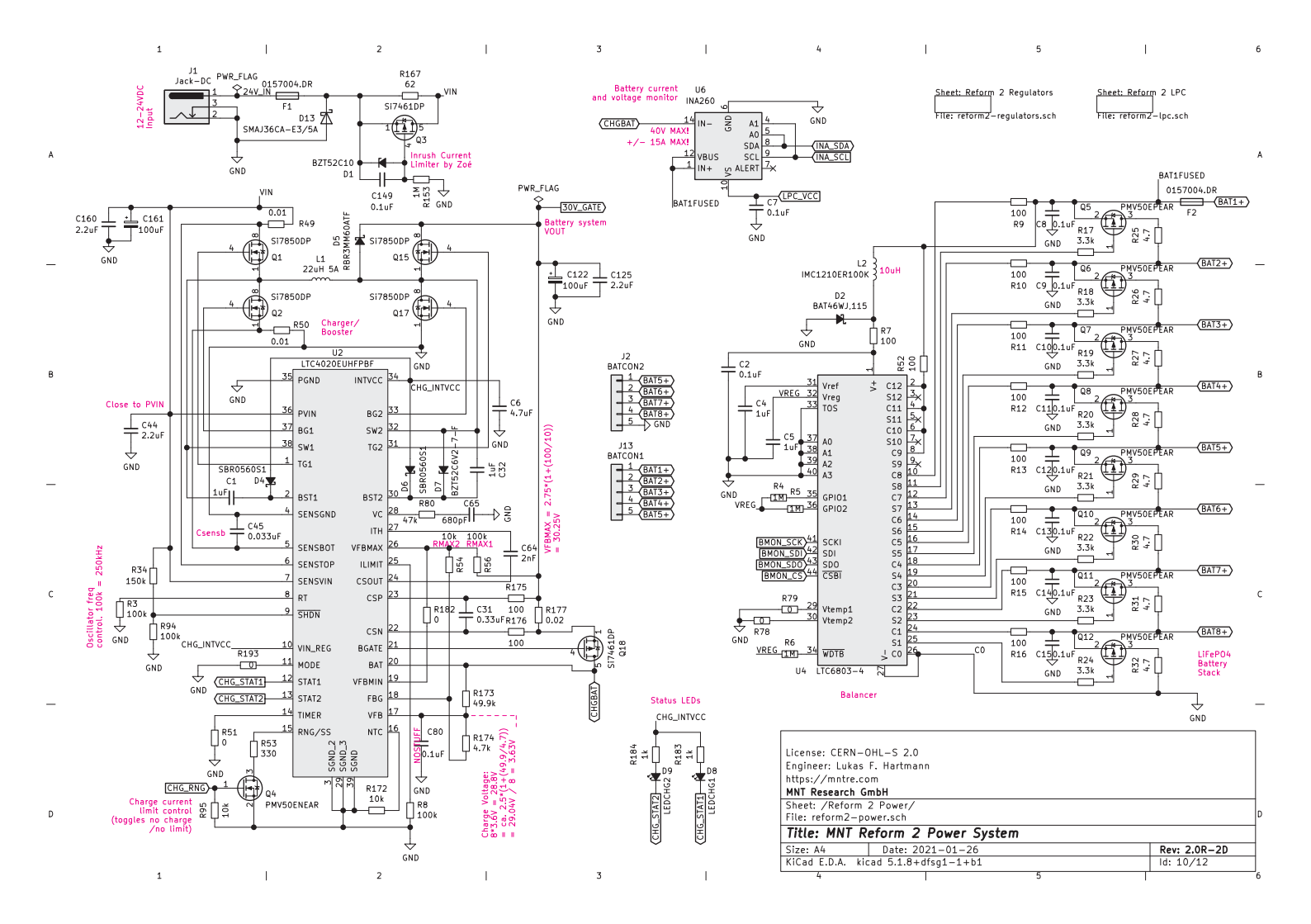
Sheet: /Reform 2 USB/Reform 2 USB Power/
File: reform2-usbpwr.sch

Title: Reform 2 USB Power

Size: A4	Date: 2021-01-26	**Rev: 2.0R-2D**
KiCad E.D.A. kicad 5.1.8+dfsg1-1+b1		Id: 9/12


12–24VDC input
J1
Jack-DC
PWR_FLAG
24V_IN
0157004.DR
F1
D13
SMAJ36CA-E3/5A
R167
62
SI7461DP
VIN
Q3
BZT52C10
D1
Inrush Current Limiter by Zoé
C149
0.1uF
1M
R153
GND
Battery current and voltage monitor
U6
INA260
CHGBAT
40V MAX!
+/- 15A MAX!
IN-
IN+
VBUS
GND
A1
A0
SDA
SCL
ALERT
INA_SDA
INA_SCL
LPC_VCC
C7
0.1uF
BAT1FUSED
Sheet: Reform 2 Regulators
File: reform2-regulators.sch
Sheet: Reform 2 LPC
File: reform2-lpc.sch
C160
2.2uF
C161
100uF
R49
0.01
Q1
SI7850DP
Q2
Q15
Q17
D5
RBR3MM60ATF
L1
22uH 5A
R50
0.01
Charger/ Booster
PWR_FLAG
30V_GATE
Battery system VOUT
C122
100uF
C125
2.2uF
U2
LTC4020EUHFPBF
PGND
INTVCC
PVIN
BG2
BG1
SW2
SW1
TG2
TG1
BST1
BST2
SENSGND
VC
ITH
SENSBOT
VFBMAX
SENSTOP
ILIMIT
SENSVIN
CSOUT
RT
CSP
SHDN
CSN
VIN_REG
BGATE
MODE
BAT
STAT1
VFBMIN
STAT2
FBG
TIMER
VFB
RNG/SS
NTC
SGND_2
SGND_3
SGND
CHG_INTVCC
C6
4.7uF
Close to PVIN
C44
2.2uF
SBR0560S1
C1
1uF
D4
D6
SBR0560S1
D7
BZT52C6V2-7-F
1uF
C32
R80
47k
C65
680pF
Csensb
C45
0.033uF
10k
100k
RMAX2
RMAX1
R54
R56
C64
2nF
VFBMAX = 2.75*(1+(100/10)) = 30.25V
Oscillator freq control. 100k = 250kHz
R34
150k
R3
100k
R94
100k
R175
R182
0
C31
0.33uF
100
R176
R177
0.02
100
Q18
SI7461DP
CHGBAT
R193
0
CHG_STAT1
CHG_STAT2
R173
49.9k
R51
0
R53
330
C80
0.1uF
NOSMUFF
R174
4.7k
CHG_RNG
R95
10k
Q4
PMV50ENEAR
R172
10k
R8
100k
Charge current limit control (toggles no charge /no limit)
Charge Voltage: 8*3.6V = 28.8V = ca. 2.5*(4+(49.9/4.7)) = 29.04V / 8 = 3.63V
J2
BATCON2
J13
BATCON1
BAT1+
BAT2+
BAT3+
BAT4+
BAT5+
BAT6+
BAT7+
BAT8+
Status LEDs
R184
1k
R183
1k
D9
LEDCHG2
D8
LEDCHG1
L2
IMC1210ER100K
10uH
D2
BAT46WJ,115
R7
100
C2
0.1uF
C4
1uF
C5
1uF
R4
1M
R5
1M
VREG
GPIO1
GPIO2
BMON_SCK
BMON_SDI
BMON_SDO
BMON_CS
SCKI
SDI
SDO
CSBI
R79
0
R78
0
Vtemp1
Vtemp2
R6
1M
WDTB
U4
LTC6803-4
Balancer
R52
100
C0
BAT1FUSED
0157004.DR
F2
BAT1+
R9
100
C8
0.1uF
Q5
PMV50EPEAR
R17
3.3k
R25
4.7
R10
100
C9
0.1uF
Q6
R18
3.3k
R26
4.7
R11
100
C10
0.1uF
Q7
R19
3.3k
R27
4.7
R12
100
C11
0.1uF
Q8
R20
3.3k
R28
4.7
R13
100
C12
0.1uF
Q9
R21
3.3k
R29
4.7
R14
100
C13
0.1uF
Q10
R22
3.3k
R30
4.7
R15
100
C14
0.1uF
Q11
R23
3.3k
R31
4.7
R16
100
C15
0.1uF
Q12
R24
3.3k
R32
4.7
LiFePO4 Battery Stack
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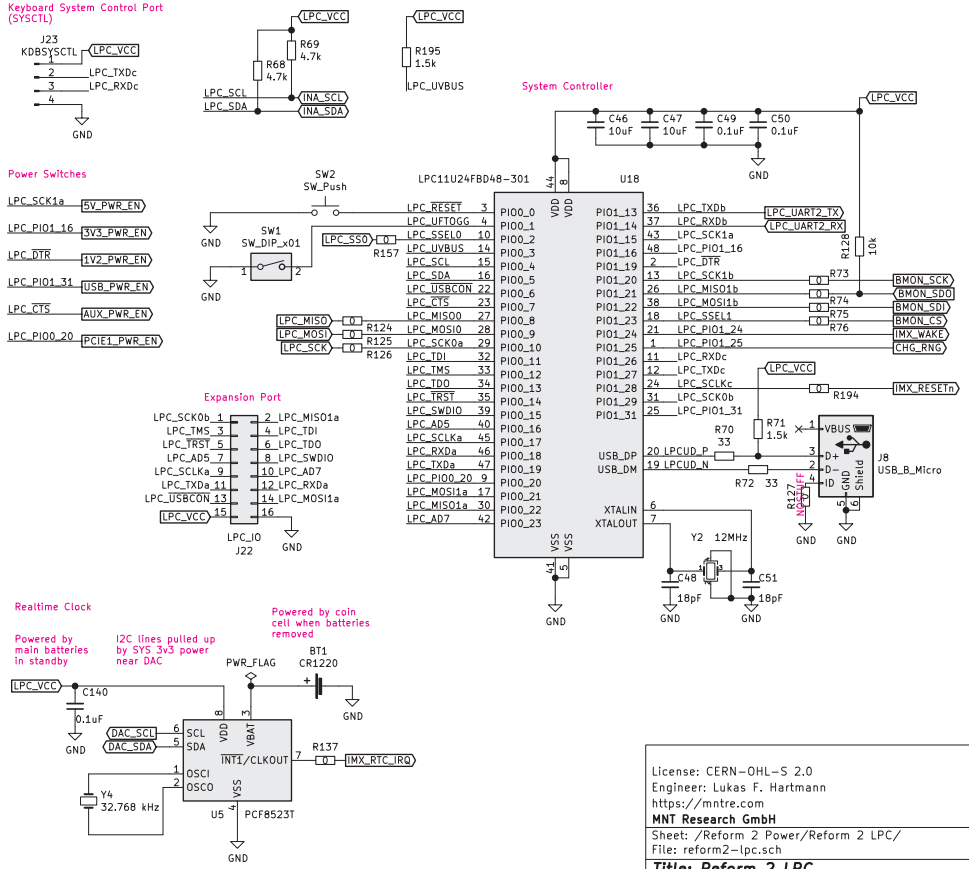
Engineer: Lukas F. Hartmann
https://mntre.com
MNT Research GmbH
Sheet: /Reform 2 Power/
File: reform2-power.sch
Title: MNT Reform 2 Power System
Size: A4
Date: 2021-01-26
Rev: 2.0R-2D
KiCad E.D.A. kicad 5.1.8+dfsg1-1+b1
Id: 10/12



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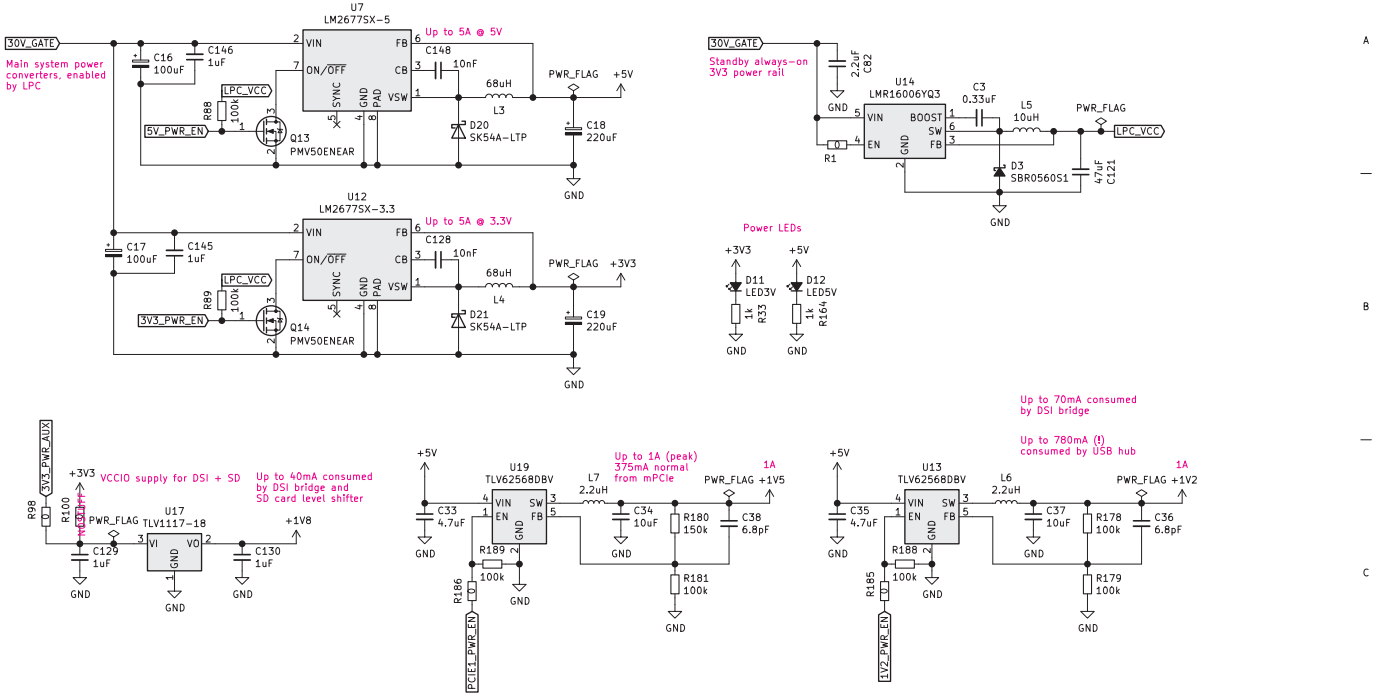
Engineer: Lukas F. Hartmann
https://mntre.com
MNT Research GmbH

Sheet: /Reform 2 Power/Reform 2 LPC/
File: reform2-lpc.sch

Title: Reform 2 LPC

Size: A4	Date: 2021-01-26	**Rev: 2.0R-2D**
KiCad E.D.A. kicad 5.1.8+dfsg1-1+b1		Id: 11/12



Engineer: Lukas F. Hartmann
https://mntre.com
MNT Research GmbH

Sheet: /Reform 2 Power/Reform 2 Regulators/
File: reform2-regulators.sch

Title: Reform 2 Regulators

Size: A4	Date: 2021-01-26	**Rev: 2.0R-2D**
KiCad E.D.A. kicad 5.1.8+dfsg1-1+b1		Id: 12/12

11.2 Motherboard Bill of Materials

Designators	Qty	Brand	Part Number
BT1	1	Keystone	3000
C1 C4-C5 C32 C100 C111 C114 C129-C130 C141 C145-C146 C162-C163	14	Taiyo Yuden	UMK107BJ105KA-T
C2 C7-C15 C22-C30 C39-C42 C49-C50 C53-C57 C59-C61 C66-C67 C70 C73-C77 C80 C84-C90 C92-C97 C101 C103 C105-C110 C113 C115 C118-C119 C135-C136 C138 C140 C142-C144 C149 C154 C156 C158 C165-C166 C168-C169	82	Yageo	CC0603JPX7R9BB104
C3 C31	2	TDK	C1608X7R1H334K080AC
C6 C33 C35 C139 C151 C170	6	TDK	C1608X5R1V475K080AC
C16-C17	2	UCC	EMZR500ARA221MHA0G
C18-C19	2	UCC	EMZR500ARA221MHA0G
C20-C21 C48 C51 C62 C98	6	Yageo	CC0603JRNPO9BN180

Designators	Qty	Brand	Part Number
C34 C37 C43 C46-C47 C63 C69 C71-C72 C81 C91 C99 C112 C120 C131-C134 C137 C150 C155 C164 C167	23	Murata	GRM188R6YA106MA73D
C36 C38	2	Vishay	VJ0603A6R8DXQCW1BC
C44 C82 C125 C160	4	Taiyo Yuden	UMK107BBJ225KA-T
C45	1	KEMET	C0603C333J4REC7411
C52 C58 C102 C104 C116-C117 C128 C148 C152-C153	10	KEMET	C0603C103K5RAC3190
C64 C68 C78-C79	4	Murata	GRM1885C1H202JA01D
C65	1	KEMET	C0603C681J5GACTU
C83 C121 C123-C124 C126-C127 C147	7	Murata	GRM188R60J476ME15D
C122 C161	2	Panasonic	EEE-FTH101XAP
C157 C159	2	Taiyo Yuden	TMK107B7474KA-TR
D1	1	Diodes, Inc.	BZT52C10-7-F
D2	1	Nexperia	BAT46WJ,115
D3-D4 D6	3	Diodes, Inc.	SBR0560S1-7
D5	1	ROHM	RBR3MM60ATFTR
D7	1	Diodes, Inc.	BZT52C6V2-7-F
D8	1	ROHM	SML-D12Y1WT86
D9	1	ROHM	SML-D12Y1WT86
D10	1	Littelfuse	SP0503BAHT
D11	1	ROHM	SMLEN3WBC8W1
D12	1	ROHM	SMLEN3WBC8W1
D13	1	Vishay	SMAJ36CA-E3/5A
D14-D15	2	AVX	SD0603S040S0R2
D20-D21	2	MCC	SK54A-LTP
D22	1	ROHM	SMLEN3WBC8W1

Designators	Qty	Brand	Part Number
D23	1	ROHM	SMLEN3WBC8W1
F1-F2	2	Littelfuse	0157004.DR
FB1-FB2 FB5-FB9	7	Murata	BLM18PG221SH1D
FB3-FB4 FB10-FB12 FB14-FB22	14	Murata	BLM18KG101TN1D
H1	1	Würth	9774020243R
H22 H24-H25 H27	4	Würth	9774025243R
J1	1	Switchcraft	RAPC712X
J2	1	Molex	504050-0591
J3	1	TE	1775059-1
J4	1	Würth	685119134923
J5-J6 J17	3	Würth	692121030100
J7	1	CUI	SJ-43516-SMT-TR
J8	1	Würth	629105136821
J9	1	JST	B4B-PH-K-S(LF)(SN)
J10	1	TE	1-2199230-6
J11	1	Molex	48099-5701
J13	1	Molex	504050-0591
J14	1	JST	B4B-PH-K-S(LF)(SN)
J15	1	Hirose	FH12-33S-0.5SH(55)
J16 J18 J20	2	Würth	61300311121
J19	1	Amphenol FCI	20021111-00010T4LF
J21	1	JST	B4B-PH-K-S(LF)(SN)
J22	1	Molex	87914-1616
J23	1	JST	B4B-PH-K-S(LF)(SN)
J24	1	Molex	87758-3016
L1	1	Würth	7447709220
L2	1	Vishay Dale	IMC1210ER100K
L3-L4	2	Bourns	SRR1210-680M
L5	1	Taiyo Yuden	CBC3225T100MRV
L6-L7	2	Taiyo Yuden	BRL3225T2R2M
L8-L11	4	Murata	LQH32PB150MN0L
P1	1	Pulse	J0G-0003NL
Q1-Q2 Q15 Q17	4	Vishay Siliconix	SI7850DP-T1-E3
Q3 Q18	2	Vishay Siliconix	SI7461DP-T1-E3
Q4 Q13-Q14	3	Nexperia	PMV50ENEAR

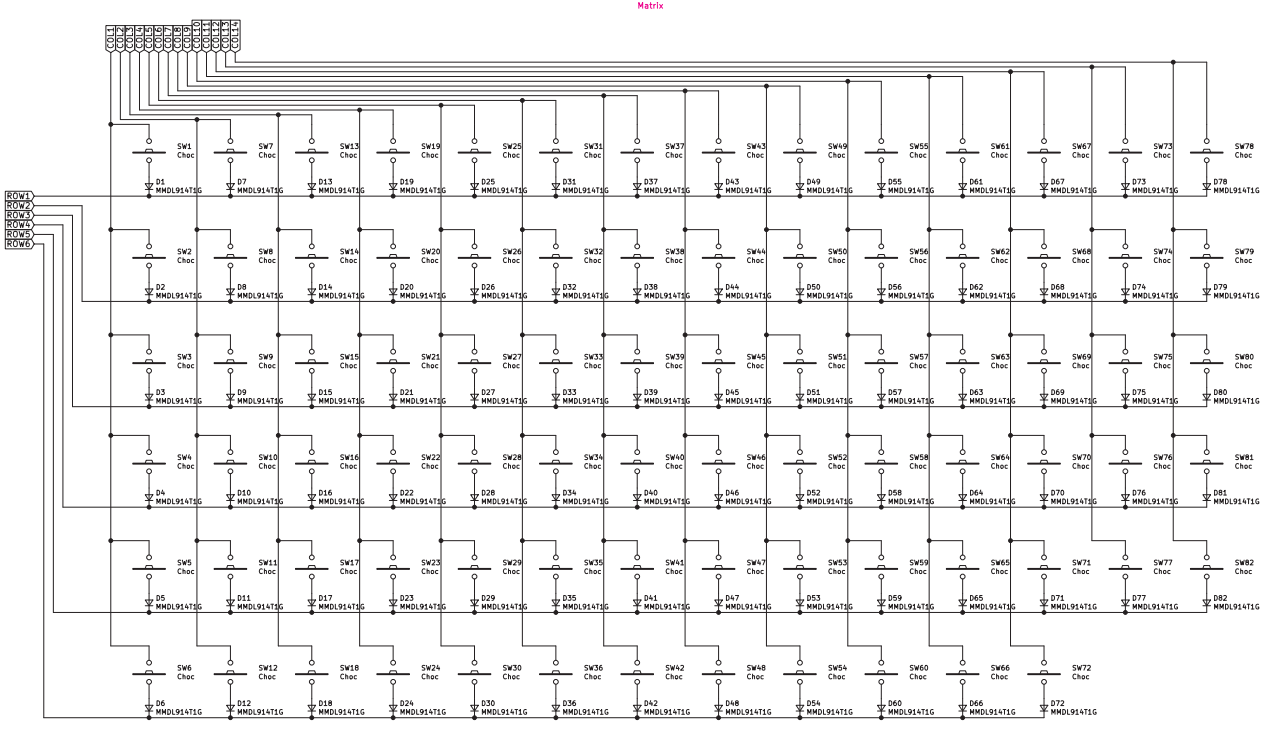
Designators	Qty	Brand	Part Number
Q5-Q12	8	Nexperia	PMV50EPEAR
R1 R39 R51 R65 R73-R79 R98 R100-R101 R104-R109 R111 R116 R124-R127 R129-R130 R137 R141 R146-R147 R152 R154-R155 R157 R182 R185-R187 R193-R194	42	Vishay Dale	CRCW06030000Z0EAC
R2 R45 R54 R83 R95 R113 R115 R117-R119 R128 R161 R172 R196	14	Yageo	RC0603FR-0710KL
R3 R8 R46 R56 R81-R82 R84-R86 R88-R89 R94 R103 R120 R160 R178-R179 R181 R188-R189	20	Vishay Dale	CRCW0603100KJNEAC
R4-R6 R41 R55 R96-R97 R153 R156	9	Yageo	RC0603FR-071ML
R7 R9-R16 R52 R175-R176	12	Vishay Dale	CRCW0603100RFKEAC
R17-R24	8	Vishay Dale	CRCW06033K30FKEAC
R25-R32	8	TE Connectivity	35224R7JT
R33 R67 R110 R164 R183-R184	6	Yageo	RC0603FR-071KL

Designators	Qty	Brand	Part Number
R34 R180	2	Vishay Dale	CRCW0603150KFKEAC
R35 R37-R38 R40 R42 R71 R102 R122 R168-R171 R195	13	Yageo	RC0603FR-071K5L
R36	1	Yageo	RC0603FR-07475RL
R43-R44 R58-R60 R63 R68-R69 R131-R132 R135-R136 R174	13	Yageo	RC0603FR-074K7L
R47-R48 R80 R142-R144 R197	7	Vishay Dale	CRCW060347K0FKEAC
R49-R50	2	ROHM	LTR18EZPFU10L0
R53	1	Yageo	RC0603FR-07330RL
R57	1	Yageo	RC0603FR-079K53L
R61	1	Vishay Dale	CRCW060390K9FKEAC
R62	1	Yageo	RC0603FR-0710KL
R64	1	Yageo	RC0603FR-0751KL
R66 R112	2	Yageo	RC0603FR-07220RL
R70 R72 R114 R121 R138-R139 R150-R151	8	Vishay Dale	CRCW060333R0FKEAC
R87 R99	2	Yageo	RC0603FR-0724K9L
R90-R93	4	Yageo	RC0603FR-0727RL
R123 R148 R198-R199	4	Yageo	RC0603FR-1049R9L
R140	1	Yageo	RC0603FR-07680RL
R167	1	Yageo	RC0603FR-0762RL
R173	1	Vishay Dale	CRCW060349K9FKEAC
R177	1	ROHM	LTR18EZPFSR020
R192	1	Bourns	CR0603-FX-2702ELF
SW1 SW3	2	Apem	DM01
SW2 SW6	2	USAKRO	UK-B0206-G3.8-250-JZ
SW5	1	Diptronics	DHA-04TQ
U1	1	TE	1717254-1

Designators	Qty	Brand	Part Number
U2	1	Analog Devices	LTC4020EUHF#PBF
U3	1	Cirrus Logic	WM8960CGEFL/V
U4	1	Analog Devices	LTC6803IG-4#PBF
U5	1	NXP	PCF8523T/1,118
U6	1	Texas Instruments	INA260AIPWR
U7	1	Texas Instruments	LM2677SX-5
U8	1	Texas Instruments	TXS0108EPW
U9	1	Texas Instruments	TUSB8041IPAPRQ1
U10	1	Texas Instruments	SN65DSI86IPAPQ1
U11	1	Molex	67910-5700
U12	1	Texas Instruments	LM2677S-3.3/NOPB
U13 U19	2	Texas Instruments	TLV62568DBVR
U14	1	Texas Instruments	LMR16006YQ3
U15-U16	2	Texas Instruments	TPS2561DRCR
U17	1	Texas Instruments	TLV1117-18CDCYR
U18	1	NXP	LPC11U24FBD48-301
U20 U24 U27	3	Diodes, Inc.	AP22815AWT-7
U21 U25-U26	3	Littelfuse	SP3012-06UTG
U22	1	Texas Instruments	TPD12S521
U23	1	IDT	5V41066PGGI8
U28	1	Texas Instruments	SN74AVC1T45
Y1	1	Abracon	ABM8AIG-24.000MHz-R40-4-T
Y2	1	Abracon	ABM8AIG-12.000MHz-2-T
Y3	1	Abracon	ABM8AIG-25.000MHz-R40-4-T

Designators	Qty	Brand	Part Number
Y4	1	ECS	ECS-.327-7-34B-TR

11.3 Keyboard Schematics



Sheet: Reform KBD MCU
File: reform-kbd-mcu.sch

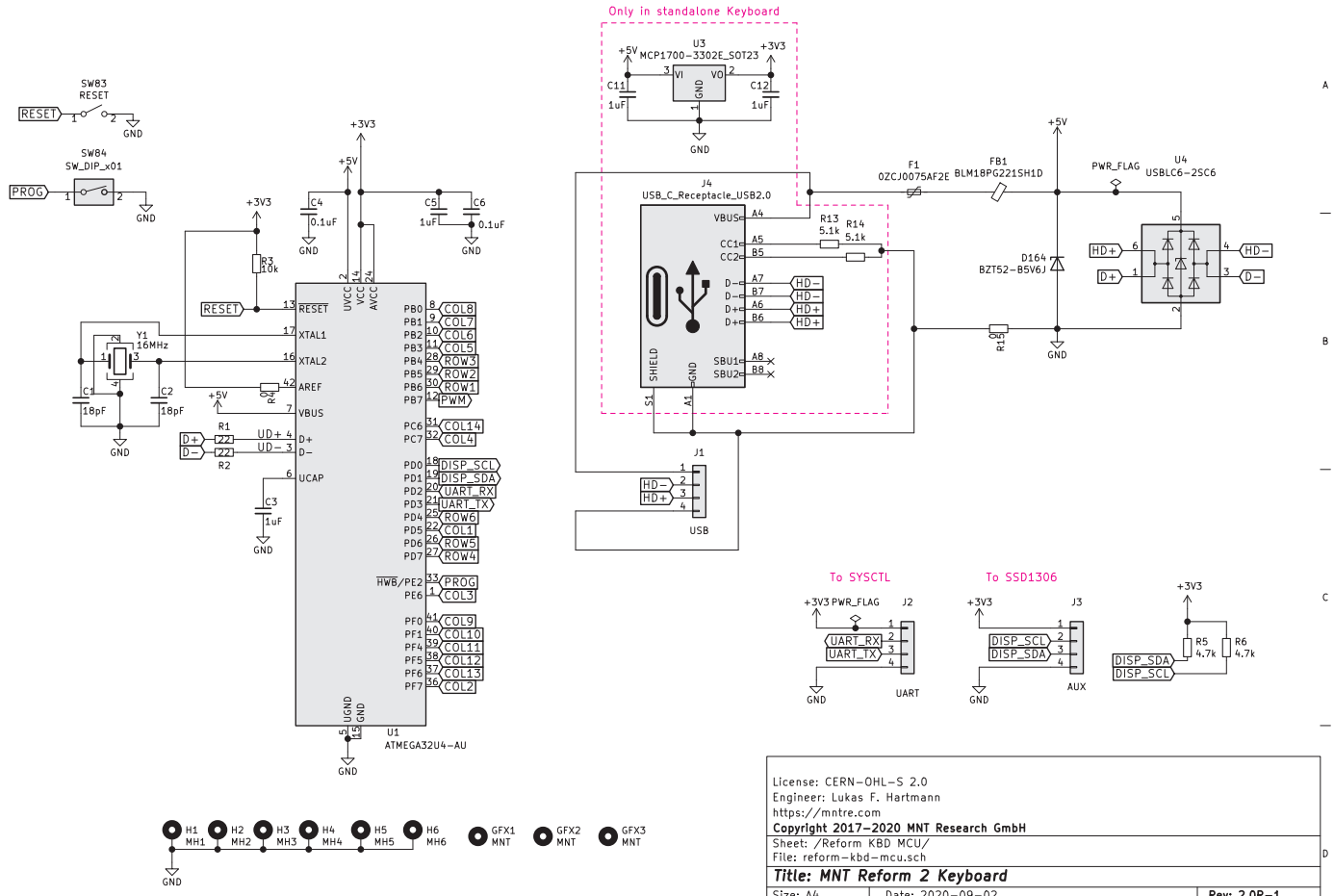
Sheet: Reform KBD Backlight
File: reform2-keyboard-backlight.sch

Engineer: Lukas F. Hartmann
https://mntre.com

Sheet: /
File: reform2-keyboard.sch

Title: MNT Reform 2 Keyboard

Size: A3	Date: 2020-09-02	Rev: 2.0R-1
KiCad E.D.A. kicad 5.1.8+dfsg1-1+b1		Id: 1/3

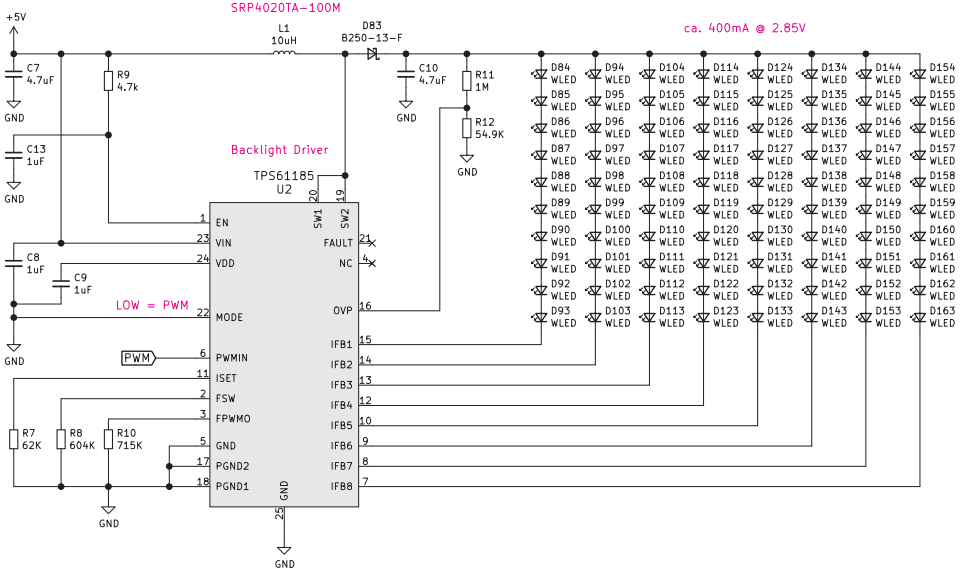


Engineer: Lukas F. Hartmann
https://mntre.com

Sheet: /Reform KBD MCU/
File: reform-kbd-mcu.sch

Title: MNT Reform 2 Keyboard

Size: A4	Date: 2020-09-02	**Rev: 2.0R-1**
KiCad E.D.A. kicad 5.1.8+dfsg1-1+b1		Id: 2/3



Engineer: Lukas F. Hartmann
https://mntre.com

Sheet: /Reform KBD Backlight/
File: reform2-keyboard-backlight.sch

Title: MNT Reform 2 Keyboard

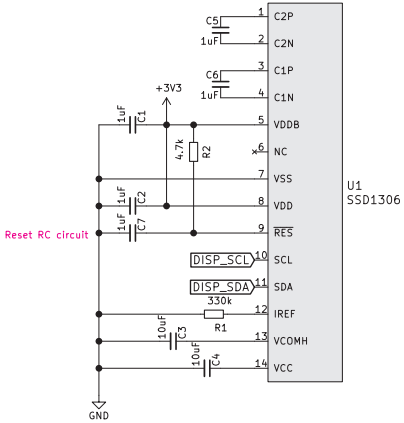
Size: A4	Date: 2020-09-02	**Rev: 2.0R-1**
KiCad E.D.A. kicad 5.1.8+dfsg1-1+b1		Id: 3/3

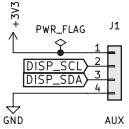
11.4 Keyboard Bill of Materials

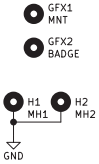
Designators	Qty	Brand	Part Number
C1-C2	2	Yageo	CC0603JRNPO9BN180
C7 C10	2	Taiyo Yuden	JMK107BB7475KA-T
C3 C5 C8-C9 C11-C13	7	TDK	C1608X8L1C105K080AC
C4 C6	2	Yageo	CC0603JPX7R9BB104
D1-D82	82	ON	MMDL914T1G
D164	1	Nexperia	BZT52-B5V6J
D83	1	Diodes	B250-13-F
D84-D163	80	OSRAM	LW Q38E-Q2OO-3K5L
F1	1	Bel Fuse	0ZCJ0075AF2E
FB1	1	Murata	BLM18PG221SH1D
J1	1	JST	S4B-PH-SM4-TB(LF)(SN)
J2	1	JST	S4B-PH-SM4-TB(LF)(SN)
J3	1	Molex	200528-0040
J4	1	Amphenol	12401610E4#2A
L1	1	Bourns	SRP4020TA-100M
R10	1	Vishay Dale	CRCW0603715KFKEA
R11	1	Yageo	RC0603FR-071ML
R12	1	Yageo	RC0603FR-0754K9L
R13-R14	2	Panasonic	ERJ-3EKF5101V
R1-R2	2	Vishay Dale	CRCW06030000Z0EAC
R3	1	Yageo	RC0603FR-0710KL
R4 R15	2	Vishay Dale	CRCW06030000Z0EAC
R5-R6 R9	3	Yageo	RC0603FR-074K7L
R7	1	Vishay Dale	CRCW060362K0FKEAC
R8	1	Vishay Dale	CRCW0603604KFKEA
SW1-SW82	82	Kailh	CPG135001D02
SW83	1	C&K	KMR221GLFS
SW84	1	Apem	DM01
U1	1	Microchip	ATMEGA32U4-AU
U2	1	Texas Instruments	TPS61185RGET
U3	1	Microchip	MCP1700T-3302E/TT
U4	1	ST	USBLC6-2SC6
Y1	1	Abracon	ABM8AIG-16.000MHz-4-T

11.5 OLED Schematics

SSD1306 OLED
Circuit based on Adafruit 931







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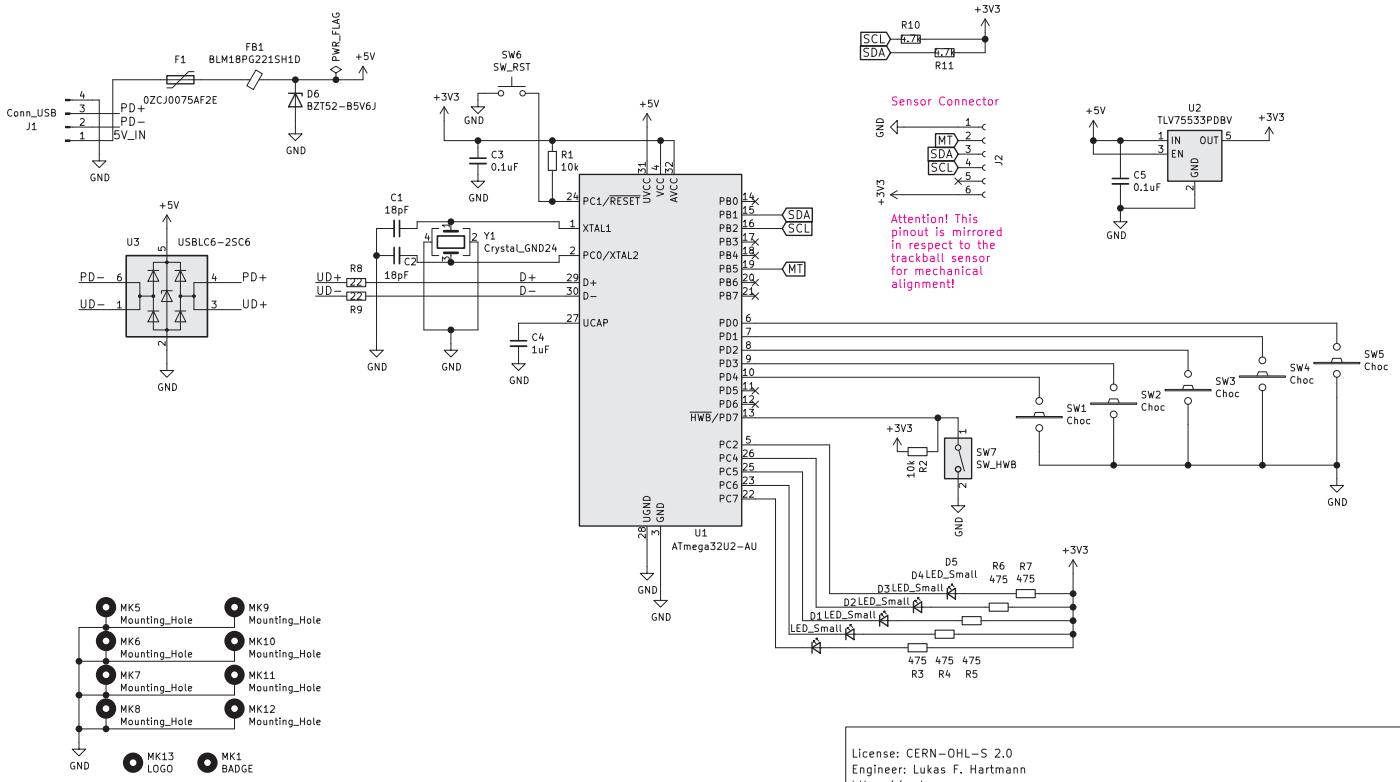
Sheet: /
File: reform2-oled.sch

Title: MNT Reform 2 Keyboard OLED

Size: A4	Date: 2020-09-08	**Rev: 2.0R-1**
KiCad E.D.A. kicad 5.1.8+dfsg1-1+b1		Id: 1/1

Designators	Qty	Brand	Part Number
C3 C4	2	Taiyo Yuden	LMK107BBJ106KALT
C5 C6 C1 C2 C7	5	Taiyo Yuden	UMK107BJ105KA-T
J1	1	Molex	200528-0040
R1	1	Yageo	AF0603FR-07330KL
R2	1	Yageo	RC0603FR-074K7L
U1	1	Enrich Electronics	ENH-OB00910003

11.6 Trackball Schematics



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Sheet: /
File: reform2-trackball.sch

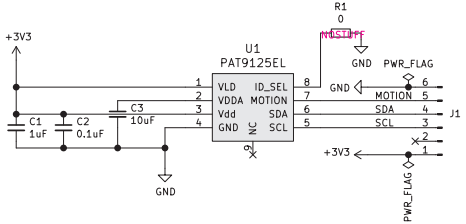
Title: MNT Reform 2 Trackball

Size: A4	Date: 2020-09-08	**Rev: 2.0R-1**
KiCad E.D.A. kicad 5.1.8+dfsg1-1+b1		Id: 1/1

11.7 Trackball Bill Of Materials

Designators	Qty	Brand	Part Number
C1 C2	2	Yageo	CC0603JRNPO9BN180
C3 C5	2	Yageo	CC0603JPX7R9BB104
C4	1	TDK	C1608X8L1C105K080AC
D5 D4 D3 D2 D1	5	OSRAM	LW Q38E-Q2OO-3K5L
D6	1	Nexperia	BZT52-B5V6J
F1	1	Bel Fuse	0ZCJ0075AF2E
FB1	1	Murata	BLM18PG221SH1D
J1	1	JST	B4B-PH-K-S(LF)(SN)
J2	1	Hirose	FH12-6S-0.5SH(55)
R10 R11	2	Yageo	RC0603FR-074K7L
R2 R1	2	Vishay Dale	CRCW060310K0JNEAC
R7 R6 R5 R4 R3	5	Yageo	RC0603FR-07475RL
R8 R9	2	Yageo	RT0603DRD0722RL
SW5 SW4 SW3 SW2 SW1	5	Kailh	CPG135001D02
SW6	1	C&K	KMR221GLFS
SW7	1	Apem	DM01
U1	1	Microchip	ATMEGA32U2-AU
U2	1	Texas Instruments	TLV75533PDBVR
U3	1	ST	USBLC6-2SC6
Y1	1	Abracon	ABM8AIG-16.000MHz-4-T

11.8 Trackball Sensor Schematics



H1
MountingHole

H5
MountingHole

H7
LOGO

H8
LOGO

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File: reform2-trackball-sensor.sch

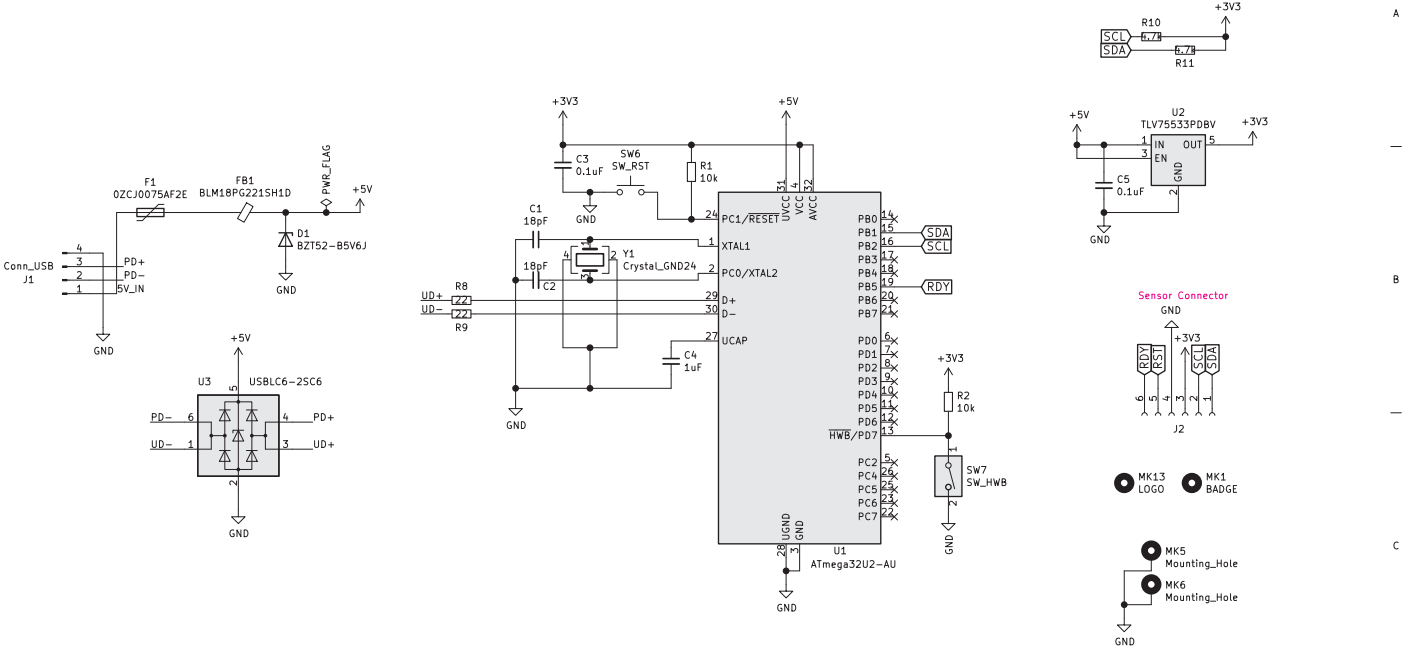
Title: MNT Reform Trackball Sensor

Size: A4	Date: 2020-09-08	**Rev: 2.0R-1**
KiCad E.D.A. kicad 5.1.8+dfsg1-1+b1		Id: 1/1

11.9 Trackball Sensor Bill Of Materials

Designators	Qty	Brand	Part Number
C1	1	TDK	C1608X8L1C105K080AC
C2	1	Yageo	CC0603JPX7R9BB104
C3	1	Taiyo Yuden	LMK107BBJ106KALT
J1	1	Hirose	FH12-6S-0.5SH(55)
R1	1	–	Do Not Place
U1	1	PixArt Imaging	PAT9125EL

11.10 Trackpad Schematics



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Sheet: /
File: reform2-trackpad.sch

Title: MNT Reform 2 Trackpad

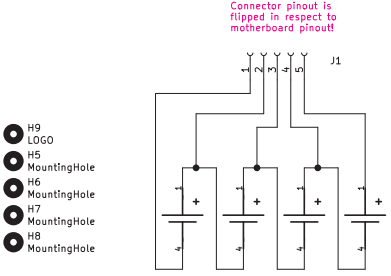
Size: A4	Date: 2020-10-03	**Rev: 2.0R-1**
KiCad E.D.A. kicad 5.1.8+dfsg1-1+b1		Id: 1/1

11.11 Trackpad Bill Of Materials

Designators	Qty	Brand	Part Number
C1 C2	2	Yageo	CC0603JRNPO9BN180
C3 C5	2	Yageo	CC0603JPX7R9BB104
C4	1	Taiyo Yuden	UMK107BJ105KA-T
D1	1	Nexperia	BZT52-B5V6J
F1	1	Bel Fuse	0ZCJ0075AF2E
FB1	1	Murata	BLM18PG221SH1D
J1	1	JST	B4B-PH-K-S(LF)(SN)
J2	1	Hirose	FH12-6S-0.5SH(55)
R10 R11	2	Yageo	RC0603FR-074K7L
R2 R1	2	Vishay Dale	CRCW060310K0JNEAC
R8 R9	2	Yageo	RT0603DRD0722RL
SW6	1	Diptronics	PTLP2
SW7	1	Apem	DM01
U1	1	Microchip	ATMEGA32U2-AU
U2	1	Texas Instruments	TLV75533PDBVR
U3	1	ST	USBLC6-2SC6
Y1	1	Abracon	ABM8AIG-16.000MHz-4-T

11.12 Battery Pack Schematics

Connector pinout is flipped in respect to motherboard pinout!



H9
LOGO
H5
MountingHole
H6
MountingHole
H7
MountingHole
H8
MountingHole

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Sheet: /
File: reform2-batterypack.sch

Title: MNT Reform 2 Battery Pack

Size: A4	Date: 2020-04-11	**Rev: 2.0R-1**
KiCad E.D.A. kicad 5.1.8+dfsg1-1+b1		Id: 1/1

11.13 Battery Pack Bill Of Materials

Designators	Qty	Brand	Part Number
J1	1	Molex	504050-0591
U1-U8	8	Keystone	54

11.14 Assembly Parts

Part	Qty	Brand	Part Number
USB/SYSCTL Cable JST-PH 4P	3	MNT Research	MREFCBLU20R01
Speaker Cable JST-PH 4P	1	MNT Research	MREFCBLS20R01
eDP I-PEX to DuPont 2mm 2×15P Cable	1	MNT Research	MNT190722001
Sensor Cable 6P 50mm 0.5mm Pitch	1	Würth Elektronik	687606050002
OLED Cable 1mm Pitch 50mm	1	Würth Elektronik	686704050001
MIPI-DSI Cable FPC 0.5mm 33P 50mm	1	Würth Elektronik	687733050002
Battery Cable Picolock	2	Molex	151320502
Bottom Plate Acrylic Transparent	1	MNT Research	MREFCBPL20R01
Keyboard Frame Al6061 Black	1	MNT Research	MREFCKBF20R01
Main Box Al6061 Black	1	MNT Research	MREFCMBT20R01
Keyboard Frame Al6061 Black	1	MNT Research	MREFCMHS20R01
Left Port Cover Acrylic Black	1	MNT Research	MREFCPCL20R01
Right Port Cover Acrylic Black	1	MNT Research	MREFCPCR20R01
Screen Back Al6061 Black	1	MNT Research	MREFCSCB20R01
Screen Front Al6061 Black	1	MNT Research	MREFCSCF20R01
Right Hinge	1	Smooth Technology	SMS-ZZ-219-L

Part	Qty	Brand	Part Number
Left Hinge	1	Smooth Technology	SMS-ZZ-219-R
Neodymium Bar Magnet	8	MNT Research	MREFDMAG20R01
Rubber Foot Transparent	4	Modulor	0303782
M2 Flat Washer NF E 25-514	4	Accu	HAFZ-M2-A2
Screw M4×5 Countersunk DIN 965H	6	Accu	SIK-M4-5-A2
Screw M2×12 Countersunk DIN 965H	4	Accu	SIP-M2-12-A2
Screw M2×6 Countersunk DIN 965H	18	Accu	SIK-M2-6-A2
Screw M2×4 Pan Head DIN 7985H	30	Accu	SIP-M2-4-A2
Screw M2×5 Black Countersunk DIN 965H	23	Generic	–
Trackball Button Big (SLA)	2	MNT Research	MREFXTB120R01
Trackball Button Small (SLA)	3	MNT Research	MREFXTB220R01
Trackball Cup (SLA)	1	MNT Research	MREFXTBC20R01
Trackball Lid (SLA)	1	MNT Research	MREFXTBL20R01
Trackpad Holder (SLA or FDM-PETG)	1	MNT Research	MREFXTPH20R01
Speaker Holder (SLA)	2	MNT Research	MREFXSPK20R01
POM Ball Black 25mm	1	MNT Research	MREFBALB20R01
Motherboard PCBA	1	MNT Research	MREFAMOB20R02
Keyboard PCBA	1	MNT Research	MREFAKBD20R01
OLED PCBA	1	MNT Research	MREFAOLE20R01
Trackball Controller PCBA	1	MNT Research	MREFATBC20R01
Trackball Sensor PCBA	1	MNT Research	MREFATBS20R01
Trackpad Controller PCBA		MNT Research	MREFATPC20R01
Trackpad Sensor		Azoteq	TPS65-201A-B
Battery Pack PCBA	2	MNT Research	MREFABAT20D03
Display Panel eDP IPS 12.5”	1	Innolux	N125HCE-GN1
Speaker	2	PUI Audio	AS01808AO-3-R

Part	Qty	Brand	Part Number
Keycap 1U	72	MNT/FKcaps or Kailh	BSPG1350-06001P2
Keycap 1.5U	10	MNT/FKcaps or Kailh	BSPG1350-06009
CPU Module i.MX8M	1	Boundary Devices	Nit8MQ_SOM_4r16e
Piñatex Sleeve (Reform Max)	1	MNT Research	MREFSLBP20R01
Operator Handbook (Reform Max)	1	MNT Research	MREFBOOK20R01
Power Supply 24V 2.5A 60W	1	Mean Well	GST60A24
Power Cable IEC 60320 C14	1	Depending on Region	–
Battery Cell LiFePO4 18650	1	JGNE	HTCFR18650

Chapter 12

Online Resources

Get the latest news and additional resources for your MNT Reform at:

- The MNT Research website (with links to social media): `https://mntre.com`
- Source code repositories (including electronics design files and 3D models for printing and laser cutting): `https://source.mnt.re/reform`
- MNT Reform on Crowd Supply: `https://www.crowdsupply.com/mnt/reform`
- For email support, contact: `support@mntre.com`

You can join fellow MNT Reform enthusiasts in the official IRC channel `#reform` on `irc.freenode.net`.

Discover more about the main software building blocks of the MNT Reform system:

- Debian GNU/Linux: `https://debian.org`
- U-Boot: `https://www.denx.de/wiki/U-Boot`
- Sway: `https://swaywm.org`
- GNOME: `https://www.gnome.org`

Chapter 13

Credits

The MNT Reform Operator Handbook, First Edition. Berlin, January 2021. Written by Lukas F. Hartmann. Published by MNT Research GmbH.

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Quality & Assembly, Sleeve Design Greta Melnik

Sleeve Assembly Magda Abdel Hafith

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Sven Gebhardt, Jan Varwig, Gabriel Yoran, Martin Meyerhoff, Stefan Kalkowski, GyrosGeier, Philipp Dikmann, Michael Christophersson, Markus Angermeier

Therapy Dog Tina

Crowdfunding Partner Crowd Supply

Additional Funding NLNet, Mozilla MOSS

Printed Circuit Boards PCBWay

Milling JPR

Inter Font @rsms

Lab Tools Rigol DS1054Z, Fluke 117, Weller WD-1, Puhui T-962C, AmScope SM-4T, BCN3D Sigma R17, Formlabs Form2, Epilog Mini 18

Software Debian GNU/Linux, KiCAD, Inkscape, GIMP, Emacs, Vim, GitLab, LUFA, MicroBuilder, Blender, FreeCAD, OpenSCAD, Fusion, Cura, Sphinx, Pandoc, XeTeX, Scribus

We don’t have to be mean, cause, remember:
no matter where you go, there you are.